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INTERCEPTOR SEWERS AND SUBURBAN SPRAWL: THE IMPACT OF CONSTRUCTION GRANTS ON RESIDENTIAL LAND USE

VOLUME I. ANALYSIS

URBAN SYSTEMS RESEARCH AND ENGINEERING, INCORPORATED

PREPARED FOR
COUNCIL ON ENVIRONMENTAL QUALITY

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The purpose of the study was to explore the extent to which funds granted by EPA for financing construction of interceptor sewers may impact residential housing patterns in the communities served by these interceptor projects, the extent to which the impacts are being evaluated in the planning, review, and EPA approval of the project grants, and the ways in which EPA policies and procedures might be modified to lessen the adverse secondary impacts of interceptor construction on current development patterns.

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EXECUTIVE SUMMARY

Introduction

In the summer of 1974 a brief study was undertaken to explore the relationships between interceptor sewer construction financed by EPA and residential development patterns in rapidly growing communities. The primary purpose of the study was to describe and analyze residential land use impacts of the EPA-sponsored interceptor projects, focusing attention on the extent to which the project design, review and approval process included a consideration of these land use implications. This summary is an abbreviated presentation of the more important study results. It includes a discussion of major interceptor planning and land use policy issues, a listing of recommendations for chnages in EPA procedure based upon this policy analysis, and a very brief description of the two major components of the study--a statistical analysis of data gathered on fifty-two interceptor projects and case studies of the project planning process in eight communities.

This study was performed by Urban Systems Research and Engineering, Inc. (USR&E) under a contract with the President's Council on Environmental Quality. A two-volume report was prepared which provides a description of study methodology, a detailed discussion of the policy issues and study recommendations, an analysis and presentation of the data from the fifty-two-site statistical study, and individual case study reports on each of the eight local interceptor projects visited during the course of the study.

Interceptor Planning and Land Use Policy Issues

Since housing patterns--and particularly the phenomena of suburban sprawl--are a result of a complex set of historical, economic, social and political interactions, one must view interceptor sewer construction as only a contributing rather than decisive factor in shaping future residential land use. Though recent water quality regulations have made sewers necessary for development in some areas (and have occasionally halted new development), the absence of federally financed interceptors is unlikely to prevent low-density housing construction. Without effective, comprehensive land use planning and controls, developers will continue to repond to the great demand for single family housing by building where environmental constraints are less severe or providing sewerage facilities that meet environmental protection standards.

However, this is not to say that the building of interceptors has no influence on housing development patterns. The availability of sewers is an incentive to development, and the routing, sizing and timing of new interceptor construction can be a valuable tool for guiding residential land use as part of a comprehensive master plan. But in order for this to be effective, land use and sewer planning must be more carefully coordinated than they are at present. If the federal government wishes to encourage careful land use planning and control at a local level, it can begin by evaluating the extent to which the current design review and approval process for federally financed interceptors takes into account the land use implications of new sewer construction.

In the course of this study, USR&E identified aspects of the current EPA grant process which raise questions concerning interceptor planning and land use policy. It appears that procedures now employed in the physical design of the intercepotrs, the local review of project plans and the local and federal methods of project financing have important land use implications which have not been given adequate recognition or evaluation. The questions raised are outlined below and discussed at length in the Policy Analysis section of the study report (Volume I, Section 2).

- The Physical Design of Interceptors

  Our study results indicate that project engineers often design unnecessarily large and extensive interceptor projects in response to local development pressure. Interceptor lines are sized with tremendous excess capacity and designed to serve the ultimate, highest density population anticipated for large service areas now containing large tracts of vacant, developable land. This practice raises three questions which should be given serious consideration:

- --Do land use and population projections tend to be self-fulfilling?
- --Is the standard per capita water use formula employed in sizing interceptors too high?
- --Should design life periods for interceptor construction be reduced?

o Local Planning and Review Procedures

Based on the eight case studies performed, USR&E found little evidence that the local planning/review process included a careful assessment of the potential adverse secondary impacts of interceptor construction. Since EPA now relies heavily on the local community to make this assessment, one must ask:

- --Do local land use planning agencies play a useful role in interceptor planning and review?
- --Does the environmental impact review process deal effectively with land use impacts?
- --Is the public aware of the land use impacts of interceptor construction?

--Are the impacts of the interceptor on energy consumption being considered in the planning process?

- Local and Federal Funding Procedures

Study findings indicate that current financing procedures--on both the local and federal level--may encourage the construction of sewerage systems tailored to the needs of future developers rather than the control of pollution problems. Where communities intend to finance the 25% local share of project costs by assessing connection fees on new development (or by employing similar development-dependent loan repayment procedures), this creates pressure to encourage rapid growth and thus ensure the financial viability of the project. The federal financing procedure also has future land use implications, albeit of a different nature. Communities often view the EPA program as a one-time-only opportunity to obtain federal funds, and thus there is a definite incentive to design a future-oriented system. These results raise two important questions:

--What are the land use impacts of alternative methods of financing the local share of interceptor costs?

--What are the land use implications of alternative EPA financing policies?

Study Recommendations

The policy analysis performed as a part of this study suggests that certain changes could be made in current EPA procedures to encourage local communities to coordinate interceptor construction and land use planning and to ensure that federal monies are used for their primary purpose--pollution control--and not the subsidy of low density residential development of vacant land. USR&E offers the following recommendations for changes in EPA procedure in the hope that they will provide a focus and stimilus for discussion.

- Do Not Provide Federal Funds for Excess Capacity

  EPA should participate in financing only that portion of the interceptor project costs which represent the sewer capacity necessary to serve the needs of the existing population. That portion of the cost which represents excess capacity designed to accommodate future populations should be financed solely by local funds. This reduced financing level will enable EPA to fund more projects and thus further the pollution control objective of the Construction Grants Program. This change may also encourage local communities to consider more carefully the design of the interceptor systems--and the incentives they wish to provide developers in the form of available sewerage facilities.

- Re-evaluate Interceptor Staging of Project Design in Rapidly Growing Areas

  As a general rule, the design life of interceptors should be established at a maximum of twenty-five years, rather than at the current fifty year/ultimate population design period. If and when the high population projections now used in interceptor design make expansion necessary, parallel lines can be laid. This practice will take advantage of economies of scale in interceptor construction, without committing large sums of money to installing excess capacity with a low present value.

- Use Realistic Standards for Per Capita Flow

  The frequent practice of encouraging engineers to size interceptors on the basis of a standard 100-125 gpcd water use measure should be replaced by employing actual water use statistics. There is evidence that the standard 100 gpcd measure is excessive for many areas, and its use simply builds in additional excess capacity. In some cases the recognised safety margin of the 100 gpcd standard encourages engineers to perform only superficial calculation of other design criteria (such as infiltration/inflow); this practice would be discouraged by abandonment of the standard per capita flow measure.

- Improve Population Forecasting Techniques and Review Procedures

  Population forecasts used in interceptors design should be better justified in the grant applications submitted. Project sponsors should carefully document the anticipated sources of growth and describe in detail the methodology used in reaching the design year population statistic on which pipe sizes are based. In addition, all population projections developed by public and private agencies in the community should be included in the application, with an explanation of any discrepancies among these various estimates. Though population forecasting is always difficult, these requirements will at least ensure that more attention is paid to this very important aspect of the planning process.

- Require Consideration of Environmental Effects of Interceptor-Induced Land Use

  The potential adverse secondary impacts of large scale interceptor construction should be given more detailed assessment at the local project level prior to EPA approval of the project plans. This can be encouraged by institution of the following procedures:

1. All projects which involve the opening of vacant land for development should be required to submit an assessment of environmental impact which includes a full consideration of the secondary effects of growth.

2. For projects above a certain size (determined by EPA) an Environmental Impact Statement should be routinely prepared which includes a complete assessment of adverse secondary impacts.

o Increase Public Participation in the Planning Process by Publicizing Community Costs and Benefits of Interceptor-Induced Growth

1. Every effort should be made to publicize the project in the community prior to grant approval, to enable residents to become involved in project planning before the plans are well established.

2. Notices advertising the public hearing should be more prominent and should include the expected cost of the project to the community, the future growth (in population and location) the project is designed to serve, and the anticipated additional services which the community must provide to accommodate this growth.

3. At the public hearing, these secondary effects of the projects should be discussed as part of a full presentation of the environmental impact of the project.

We believe that these suggestions for change in EPA procedures are conservative ones and are fully justified by the case studies and the analysis conducted in the course of this study. They are discussed at greater length in Volume I, Section 3 of the study report.

The Fifty-Two Project Study: Interceptor Design and Land Use Data Analysis

To study the relationship between sewer design and future patterns of residential degelopment, USR&E analyzed statistical data from fifty-two EPA projects where high excess capacity and a large proportion of vacant land in the project service area indicated the proposed interceptors might have significant land use impacts.* The first stage of this fifty-two site study was simply a statistical description of the projects. Then as analysis of the design and cost data was performed, yielding findings on economies of scale in interceptor construction and an assessment of the costs of building excess capacity.

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*These projects were selected from a list of the 160 interceptor projects (in three federal regions) that had reached the stage of construction. The sample excluded projects which merely replace deteriorated sewers, and left projects with new construction only. Choosing among these projects could not be exact, and errors in original estimates of excess capacity were sometimes substantial. Thus, the sample is more random than first thought and includes some small projects with little excess capacity. This tends to extend the significance of the findings. Strictly speaking, however, the conclusions we reach have relevance to EPA projects involving new construction in suburban areas, rather than all new construction, some of which is going on in well-developed areas.

The statistical data has important implications for land use planning. The analysis performed demonstrated that, in the typical case, the federal government is funding projects with large excess capacity in suburban areas with rapid growth. Generally, over half the land served by a project is vacant. The mean cost of the excess capacity is $145 per capita based on the existing population and 75% of that, or about $108, is being paid by EPA. Clearly, EPA is funding the future development of vacant land on a large scale.

Of equal interest is the fact that the typical case has a high growth rate--a mean of 7%, a median of 2%. In our analysis of staging by reducing the design period, we found that if a project involved a population growth of 3%, and even if future construction becomes twice as expensive in real terms as it is now, a twenty-five year design period is cheaper than a fifty year design period. Yet the median design period of the projects studied is over fifty years, the mean 105 years. We must conclude that the great amount of money being spent to subsidize the sewering of vacant land is not even being spent in the most cost effective manner. If we pro-rate the expense of building the interceptors equally between vacant and settled land, then more than half of the government funds are being inefficiently spent to subsidize the development of vacant land.

It is necessary, of course, to bear in mind that the fifty-two project sample selected was not random, but was oriented toward projects with large excess system capacity. However, considering the random normal distribution of the proportion of vacant land in the sample, and the sketchy quality of the data on which the sample was origianlly selected, the conclusions of the fifty-two-site study may be generalized to a certain extent. If one ignores EPA projects in which replacement sewers were being funded (which did represent a considerable portion of the remainder of the projects from which the fifty projects analyzed were extracted) then the study sample becomes more highly representative of projects in which new construction is being funded, and in which land use considerations are most important.

The Case Studies

In order to study further the land use implications of the EPA projects, we selected a sample of eight local projects (from among those in the 52-site sample) with particularly high excess capacity and the largest proportion of vacant developable land in the service area to assess in detail. These eight sites were visited, and case study reports prepared, to describe the way in which land use and related planning considerations entered into the EPA design, review, and approval process. Though information from the case studies was a prime source of data for the analysis of policy issues and the development of study recommendations discussed earlier, the reports themselves are descriptive rather than analytical. In the following paragraphs, interceptor planning process in each case study project is very briefly described. The individual case study reports comprise Volume II of the final report submitted under this contract.

Oakwood Beach, New York

The Oakwood Beach Water Pollution Control project is designed to serve the southern portion of Staten Island (Richmond County), one of the five boroughs of New York City. At present, the project service area is largely suburban and rural in character, with half of the land still undeveloped. However, as the last undeveloped section of the nation's most densely populated city, south Staten Island is now experiencing rapid residential housing development, and it is anticipated that this trend will continue.

The Oakwood Beach sewer project is clearly designed to encourage these development trends. An expressed purpose of the project is to replace the inadequate septic tank disposal systems now utilized to support new construction with a comprehensive sewage collection and treatment system which will permit more rapid, as well as higher density, residential housing development. This development is viewed as a positive phenomenon.

The case study focused on two large interceptors included in the first phase of the Oakwood Beach project--two interceptors which will cost over $40 million to construct. Though many agencies were involved in project planning and the design of the interceptors has been repeatedly revised over the five-year planning period, study staff found no evidence that any serious land use impact analysis had been performed. Some attention was given to the validity of projected population figures, but there appears to be little concern over the possible negative secondary effects of stimulating rapid residential housing construction. Despite the tremendous size and cost of the Oakwood Beach Water Pollution Control Project and the serious problems of high density development experienced in other sections of New York City, a negative environmental impact declaration was accepted and the project was approved without preparation of an Environmental Impact Statement.

Ocean County, New Jersey

Ocean County is a large residential and resort area dotted with a myriad of small municipalities. It is located on the southeastern New Jersey coast just two hours drive from New York City and within commuting distance of the major northern New Jersey industrial centers. Once an isolated summer tourist area with a small and stable permanent population, Ocean County is now the fastest growing county in New Jersey. The spread of northern New Jersey industrial areas southward and the construction of numerous high speed highways linking Ocean County to major employment center to the north has resulted in a population explosion which is expected to continue until the entire area is fully developed into low and moderate density housing patterns. The Ocean County Sewerage Authority was established in 1970 for the express purpose of providing advanced sewerage collection and treatment facilities to support recent and a ticipated development.

The case study consisted of an analysis of the land use implications of a series of interceptors approved for EPA financing as part of a project to sewer the entire northern and southern sections of the county. It is recognized that these interceptors--particularly those located in the underdeveloped southern portions of the county--will support rapid residential housing development. However, the concensus among municipal, county and state officials is that nothing will halt development in the county, and that the sewer projects cannot be used as a land use planning tool. Since the municipalities responsible for land use control have been unable to shape or to curtail new development in their areas and the developers, in the absence of a regional sewage system, can and will install other less desirable sewage disposal facilities, the local planners believe the construction of sophisticated regional sewerage systems is the only sensible way to proceed.

Fulton County, Georgia

The northern portion of Fulton County, Georgia is a largely unincorporated, sparsely settled area lying directly north of the City of Atlanta. Recently connected to Atlanta by a number of high-speed highways, North Fulton County is considered the most desirable residential area in the county, and is very rapidly developing into high-income residential neighborhoods. The case study examined several interceptor projects designed to expand the very small existing sewerage system in the area.

The interceptors funded by EPA are part of a larger program to sewer the entire North Fulton County, to permit immediate development of an area which cannot support septic tank waste disposal. Initially, the interceptors were planned by the county Public Works Department, approved by local planning agencies, and funded by EPA without any assessment of its land use implications. However, as a result of community opposition--led by residents opposed to the immediate, destructive impact of project construction on scenic and recreational areas along the interceptor routes--EPA halted funds for the project pending the completion of an Environmental Impact Statement. Though the EIS stated that adverse secondary impacts could result from rapid residential development of the service area, it concluded that lack of EPA financial support for the planned sewerage system would not stop this development, and funds for construction were released. Residents of the area are now considering a law suit to challenge this action--arguing that the project should not be approved without the imposition of land use controls to minimize secondary impacts.

Horn Lake Creek River Basin, Mississippi/Tennessee

The Horn Lake Creek River Basin is a 62.5 square mile area located directly south of Memphis, Tennessee, and encompassing the northeastern portion of DeSoto County, Mississippi, and smaller portions of Shelby County, Tennessee. As the Memphis Metropolitan Area has experienced rapid population increases over the past ten years, the Horn Lake Creek Basin has become a prime location for moderate income housing development as a result of its proximity to Memphis and the availability of large tracts of relatively inexpensive land. The EPA sponsored interceptor project is a joint Mississippi/Tennessee effort designed to prevent continued pollution of Horn Lake Creek, which flows northwest through the basin and into Memphis.

Planning for this project has been complicated by the need to coordinate the efforts of a variety of agencies--local sewer districts, municipal, county, and regional planning organizations, as well as municipal, county and state government sponsors. However, the land use impacts of the project have not been considered an important aspect of this planning. Everyone involved appears to agree to the continued development of this area into moderate income residential neighborhoods, and there has been no assessment of potential secondary effects of the project which might well strain the very limited resources of the rural county where rapid development is anticipated.

Southaven, Mississippi

Southaven is a small unincorporated area lying within the Horn Lake Creek River Basin in the extreme north central portion of DeSoto County, Mississippi, just south of the Tennessee/Mississippi state line. As major highways have linked this area to the city of Memphis (located directly to the north), residential development from this rapidly growing metropolitan area has spilled over into Southaven. The Southaven Utility District (SUD) was formed in 1967 to provide sewer, water, and fire protection services to the moderate income housing subdivisions which have been constructed in response to the high development pressures. The SUD is currently responsible for all sewage collection and treatment with its district boundaries. However, with the completion of the Horn Lake Creek Interceptor (which will transport all sewage from Southaven into Memphis for advanced treatment and disposal), Southaven will construct and maintain only the collection systems and small interceptors necessary to serve its area.

As with the planning for the Horn Lake Creek Interceptor, land use impact considerations played only a minor role in the process of design and EPA approval of the two new interceptors which will be constructed in Southaven. All officials interviewed expressed the attitude that continued development was desirable and that the Utility

District should provide sewerage service in direct response to development plans. Though it is recognized that the rural county tax base cannot support urban services, this problem is not considered relevant to sewer service planning.

St. Bernard Parish, Louisiana

St. Bernard Parish (County) is an unincorporated area which serves both as a bedroom suburb of New Orleans, Louisiana, and as a location for heavy industry. On a percentage of population basis, St. Bernard Parish has been the most rapidly growing parish in the New Orleans SMSA, and the population of the center city is still moving into surrounding suburban communities. Though the parish now has several small sewage collection and treatment systems, these systems are not adequate to serve the area, and raw sewage is dumped into the Mississippi River at several locations. Since St. Bernard has the greatest amount of vacant developable land available in the entire New Orleans SMSA, new development is expected to proceed rapidly, creating further strain on the currently inadequate waste disposal system. The EPA project (temporarily halted pending redesign of the proposed treatment plant) will provide a comprehensive sewerage collection and treatment system, correcting pollution problems in areas now inadequately sewered and sewering developable areas of the parish which have not been included within the existing systems. Thus, the purpose of the project is two-fold: to ameliorate pollution problems now being experienced and to open vacant developable land for new residential housing construction.

In the course of planning this project, there have been many changes in design, but this has been largely in response to EPA procedural requirements. Adverse secondary impacts of the project do not appear to have been an issue in planning, and neither the official planning agency review nor the environmental impact assessment mentioned this issue. In general, the consensus among planners is that stimulation of residential development is a desirable impact of the project.

Madisonville, Louisiana

Madisonville is a small, predominantly rural town located 45 minutes by car from New Orleans, Louisiana. Though the area surrounding the town has been developing rapidly--and this new development is expected to continue--Madisonville has not shared the magnitude of this growth, and rapid population increases are not anticipated because the town is older, already fairly well developed and thus less attractive to developers than the open, suburban areas which surround it. There are no current plans for annexation, and this does not appear to be an influential consideration in the design of the sewer system. However, a slow steady increase in town population--from 800 to 2500--is expected over the next 40 years.

The EPA project includes a complete collection interceptor and sewage treatment program for Madisonville to replace the ineffective septic tank disposal system now utilized. The purpose of this project is very clearly the amelioration of existing pollution problems, for Madisonville is a major pollutor of a nearby river, and sewage runoff from inadequate septic tanks is creating a definite health hazard in many sections of the town. Given this situation, both governmental agencies and the public have supported the project, and no serious consideration has been given to the impact the project may have on development or the adverse impacts of such development. Though planners anticipate that some new residential development in the town may be made possible by the installation of the sewerage system, this is viewed as a mere by-product of the effort and not as a major planning issue.

Tulsa/Broken Arrow, Oklahoma

Tulsa, Oklahoma is undergoing rapid population expansion as the metropolitan area continues to attract labor intensive heavy industry and commercial establishments. The thrust of new industrial development, as well as new residential housing construction, has been in the southeast quadrant of Tulsa and the adjacent suburb of Broken Arrow. The EPA project--a joint effort between Tulsa and Broken Arrow to develop a regional sewage collection and treatment system--is designed to replace existing treatment facilities now operating over-capacity and to provide excess capacity sufficient to support the tremendous new residential development anticipated for the area.

The issue of providing excess capacity to support the large anticipated population increases in the southeast Tulsa/Broken Arrow area provides a good illustration of the relationship between EPA grants planning and suburban sprawl. Local planners recognize that the projected sprawling residential development of this area will defeat their desire for balanced growth in and around Tulsa's core business district, for past population trends indicate that a substantial portion of the new growth in the southeast will be a result of a large scale abandonment of older, less desirable neighborhoods in the metropolitan area. However, the attitude of local officials--including the land use planners--

is that sewer service provision should not be used to shape or limit residential housing patterns, and that low density suburban housing patterns are not undesirable per se. As a result, they supported the design of excess capacity into the system and the construction of interceptors into largely vacant land areas.

When these development-oriented plans were submitted for EPA approval and financing, EPA staff were directly confronted with the issue of federal financing for the support of suburban sprawl housing patterns. However, EPA avoided resolution of this issue by disallowing some proposed interceptors serving land which was not anticipated to be developed in the immediate future, but approving the construction of excess capacity in the trunk lines to accept flow from these interceptors when they are eventually built. Thus, a temporary restriction of capacity was effected which did not restrict future options in the system.

When these development-oriented plans were submitted for EPA approval and financing, EPA staff were directly confronted with the issue of federal financing for the support of suburban sprawl housing patterns. However, EPA avoided resolution of this issue by disallowing some proposed interceptors serving undeveloped land areas but approving the large excess capacity of the interceptor lines routed in more developed areas. They refused to fund sewer lines which had no pollution control justification, but they refused to face the land use implications of unnecessarily large interceptors approved for federal support.

1. Introduction

This report presents the results of a study of recent grants by the U.S. Environmental Protection Agency to finance the construction of interceptor sewers. The purpose of this study was to explore the extent to which funds under this program may have impacts on residential housing patterns in the communities served by these interceptor projects, the extent to which these impacts are being evaluated in the planning review and EPA approval of the project grants, and the ways in which the EPA policies and procedures might be modified to lessen the adverse secondary impacts of interceptor construction on current development patterns.

The study was performed by Urban Systems Research and Engineering, Inc. (USR&E) under a two-month contract with the President's Council of Environmental Quality (CEQ). The study staff first identified interceptor projects which had the potential to affect future land use patterns, and then collected and analyzed data on those projects which would provide insight into the following primary issues:

(1) The extent to which the physical design parameters of the project might influence future residential land use patterns;

(2) The extent to which the projects were initiated and planned to serve communities which are currently experiencing rapid population growth, and where the construction of the interceptors will facilitate residential development of large areas

of currently vacant unsewered and developable land;

(3) The degree to which the EPA's planning, grant review, environmental impact assessments, and other grant procedures currently take into consideration the land use implications of either the physical design or location of the interceptors being proposed for federal funding.

(4) The degree to which any land use impact evaluations which are performed as part of the current grant procedure have an influence on the decision to approve these projects, to require modifications in the proposed plans, or to reject the grant application.

1.1 Study Design

Since this was a very brief study, the design for data collection and analysis was straightforward. The CEQ provided the study staff with a listing of over 160 current EPA sewage treatment grants which included funding for interceptors in three federal regions--Regions II, IV and VI. (It was anticipated--and later proved to be the case--that selection of projects from different geographical regions would ensure that diverse land use planning issues were raised--issues of no growth and strict land use controls in highly urbanized areas and issues of economic development pressure and development-oriented land use planning in areas which have yet to experience problems of over-urbanization.) Basic descriptive data on each of these projects, including the size and location of the interceptors, the current population and population projection of the interceptor service area, and the land uses and proportion of vacant and developable land within this service area, was then obtained from CEQ and from telephone interviews with regional, state and local staff responsible for the planning of these projects.

Based upon this cursory review of current projects in these three federal EPA regions, fifty-two projects were selected for further study. The objective in this sampling process was to identify those local EPA projects which have the greatest potential for influencing patterns of residential development. Thus, criteria for selecting the sample included:

--the excess capacity of the proposed interceptor (the extent to which the capacity is designed for future flow requirements rather than existing service needs);

--the amount of vacant, developable land in the service area which is currently unsewered,

--the extent to which development in the service area was anticipated to consist of residential housing, rather than commercial or industrial development.

Once the fifty-two site sample was selected, study staff visited the state water quality agencies and EPA regional offices to gather further grant information, interceptor design data, and population and land use projections on each of these projects. At this time, data charts and a brief verbal descriptions were prepared which summarized the information obtained on each project, and these were submitted to CEQ as the Interim Report on the study.

The fifty-two site data was then used as the basis for two major study tasks. First, this data was used in the selection of local areas for a case study analysis of the extent to which the EPA planning and review process at the local, state and regional office levels reflects a consideration of the land use and energy consumption implications of interceptor design and construction. Again, the sampling process was focused on identifying the projects--this time from among the fifty-two previously selected for analysis--which had the greatest potential for influencing future residential land use patterns.

In selecting the eight case study sites, the fifty-two site data was analyzed and a tentative selection was made, including in the case study sample those projects with the highest levels of excess capacity and proportion of vacant, unsewered and developable land within the service area. However, in the final selection process, some non-statistical criteria were employed, including a general assessment of the project's land use implications made by EPA staff, a bias in favor of selecting projects in each of the three regions, and consideration of the practical difficulties of collecting project data within a limited time period.

Each of these eight case study sites was then visited by a member of the study team, who spent two to three days interviewing the individuals most closely involved in project planning. Independent case study reports were then prepared. Information from the case studies, as well as from the fifty-two site data charts, was analyzed and compared, and a series of policy analysis issue papers and study recommendations were developed which summarize major findings concerning the relationship between EPA project planning and land use policies.

Simultaneously, the data from the fifty-two project sample was itself analyzed for the land use impact conclusions that could be drawn from the statistical information obtained. Using this data, study staff prepared summary statistics of selected project characteristics, analyzed the economics of scale and population density of interceptor construction, and evaluated measures of excess capacity which might be employed to identify interceptor projects which may have significant land use implications.

1.2 Limitations of the Study

The analysis of the EPA interceptor planning process as well as the specific statistical and descriptive data presented in this report does not represent an in-depth comprehensive study of the interceptor projects included in the fifty-two sites or the case study samples. Rather, this report presents the results of a brief, and often necessarily cursory, assessment of these projects made during the short study period beginning in June and ending in July 1974. Though we do believe that this study produced significant findings concerning the land use and energy implications of currently funded EPA projects, we would caution the readers of this report to view this study as a suggestive, preliminary analysis of the important issues involved.

The data collected for the fifty-two site analysis was obtained almost entirely through a review of the project files made available to study staff during two-day visits to the relevant state and regional offices. Frequently the information in the files was incomplete or contradictory, and it was often impossible to ascertain with confidence that the statistics gathered accurately reflected current project plans. Though efforts were made to supplement the documentary information sources with interviews of staff familiar with the projects, it was sometimes necessary for study staff to make their own best estimates in order to reconcile differences in available data. As a result, some specific statistics utilized in the fifty-two site analysis may prove to be outdated or otherwise inaccurate. Every effort has been made to identify data items of uncertain validity and to avoid statistical analyses which could not be justified by the quality of the data obtained. However, as the discussion of the statistical analysis of the fifty cases indicates, the results of our analyses were, in general, not inconsistent with the findings of other similar studies. Despite the inherent difficulties in the development of a consistent data set from very diverse sources, we feel confident of the overall quality of the analysis of the fifty-two interceptor projects.

Though the case studies represent a more detailed assessment of individual EPA projects, they too are limited by the time constraints on the study. As anticipated, not all individuals active in initial project planning could be interviewed, for some had left the area and others were simply unavailable for on-site or telephone interviews during the limited time devoted to case study data collection. Also as expected, case study staff did encounter some difficulty in investigating and piecing together all of the potentially relevant aspects of the planning process during the brief site visits. Despite these problems, however, the case study reports do provide a great deal of information on the land use planning aspects of the EPA projects; and taken together, these studies produced significant insights into the relationship between EPA project planning and local land use policy.

1.3 Organization of the Report

This report is presented in two volumes. In Volume I, the study findings and recommendations are presented and discussed. Volume II contains the eight independent case studies, each of which describes the EPA project planning process as it relates to land use policies in a particular county or community.

Following this Introduction, Volume I has been organized into three sections and two appendices. Section 2, the Policy

Analysis, considers the primary issue of EPA project impact on residential housing patterns by raising and discussing a series of nine policy questions--three related to the physical design of the interceptor systems, four which discuss weaknesses in the planning process, and two which consider issues of local and federal financing methods. In this section, information from both the case studies and the fifty-two-site statistical analysis was utilized to explore the ways in which current EPA policies appear to support suburban sprawl housing patterns.

Section 3 of this volume presents a series of policy recommendations based on the analysis performed. Since the policy issues are complex and often interconnected, further study of these issues should be undertaken. However, the recommendations are offered to focus and stimulate discussion of these important issues.

The final section of Volume 1, Section 4, focuses on the results of the fifty-two-site project analysis; the summary statistics from this portion of the study are presented, followed by an analysis of economies of scale in interceptor construction and a discussion of excess capacity measures which may be useful in evaluating the land use implications of the EPA projects. The data items used in the fifty-two-site analysis are described in Appendix A to this volume, and presented in tabular form in Appendix B.

Volume II is divided into eight narrative case study reports, each followed by an appendix which contains maps and statistical material describing the interceptor(s) studied. The case studies are organized by EPA Region-- New York, Atlanta, and then Dallas-- with the reports ordered alphabetically within each Region.

2. Interceptor Planning and Land Use Policy Issues

Land use patterns, and particularly the phenomenon of suburban sprawl, are the result of a complex set of historical, economic, social, and political interactions. No single factor can be isolated as the cause of current land use practices, nor is it likely that modifying any particular governmental policy would result in radical changes in future land use patterns. The role of interceptor sewers must, therefore, be seen as contributory rather than decisive.

Residential development is dependent on the availability of essential public services. Sewerage along with highways and water supply are among the most capital intensive of these services, and, therefore, are frequently the most in demand. In the past the provision of interceptor sewers frequently trailed behind other services, because of low political priorities for environmental quality. Developers of residential housing dealt with the problem of wastes through the provision of septic tanks, local package treatment systems, or discharges of raw sewage into local receiving waters.

In recent years, rising public concern for environmental quality has led to strict new water quality regulations. Ad hoc solutions to the pollution problems of new residential development have been severely restricted through the enforcement of zoning restrictions on septic tank use, bans on new connections to existing collection sewer systems, and requirements for advanced wastewater treatment. As a result of these environmental standards, the lack of sewerage has become a real bottleneck to population growth, and in some localities has effectively halted residential construction. Examples of sewer-related development constraint are described in the Tulsa-Broken Arrow and Staten Island Case Studies.

Since sewers are necessary for development in many areas, there is great potential to use them as a lever to control land use. In fact, in some instances water pollution regulations are being used as the first effective restraint on residential development in our history. However, a construction ban is a very crude tool for land use control--it prevents all types of development, desirable as well as undesirable. Because of the demand for housing, it is probable that development will increase in areas where environmental constraints are not so severe, so that construction bans may merely shift sprawl rather than prevent it. In the absence of effective, comprehensive planning and land use control, the pattern of development will be molded by the same market forces which have created the suburban sprawl which exists today. Interceptor sewer planning in isolation cannot solve this problem. As one frustrated Environmental Protection Agency official described the dilemma, "The only choice we have is whether to build sewers before the environment is destroyed or after the environment is destroyed." This attitude reflects the view that in the absence of effective land use control policies and techniques, considerations of improved water quality should take precedence over vague hopes for more desirable land use patterns.

Though sewer construction, standing alone, is not the causal factor in the creation of low density suburban housing patterns, the building of interceptors can influence residential land use by supporting new development which sprawls over a large service area or by making this pattern of housing construction more difficult. In the course of this study, USR&E identified several important aspects of the current EPA design, review, and funding process which raise serious questions concerning the role of EPA sponsored interceptors in furthering suburban sprawl. In the following section of this report, these questions will be discussed--in roughly the order they occur in the construction grants planning process.

In the initial physical design phase of the interceptor projects, it appears that current regulations and procedures encourage--or at least permit--the design of unnecessarily large and extensive sewerage systems. In numerous projects, design engineers predicted tremendous increases in the service area population, sized the sewer lines with a great deal of excess capacity to accomodate this growth, and designed the system large enough to serve the maximum ultimate density of population projected for the area. These trends in physical design raise three policy questions which should be given careful consideration:

-- Do high density land use and population projections tend to be self-fulfilling?

-- Is the standard per capita water use formula employed in sizing interceptors creating unnecessary capacity?

-- Should design life periods for interceptor construction be reduced?

These questions, and the relevent study findings, are discussed in the first three policy issue paragraphs of this section--in paragraphs 2.1, 2.2 and 2.3 respectively.

In the second series of issue papers, more general questions concerning the project planning process are explored. Based largely on the eight case studies performed, USR&E found little evidence that the local review process included a careful assessment of the potential adverse secondary impacts which development-oriented interceptor construction might create. Therefore, EPA should ask:

-- Do local land use planning agencies play a useful role in interceptor planning and review?

-- Does the environmental impact review process deal effectively with land use impacts?

-- Is the public aware of the land use impacts of interceptor construction?

-- Are the impacts of the interceptors on energy consumption being considered in the planning process?

These questions are presented and discussed, in the above order, in paragraphs 2.4-2.7.

Finally, our study suggests that current EPA project financing methods may have an impact on residential land use patterns in the interceptor service area. Both the techniques used by local project sponsors, to finance the local share of project costs and the funding policies of regional EPA offices appear to encourage the construction of interceptor systems which stimulate the rapid low-density housing construction characteristic of suburban communities. These findings are the basis for the discussion of two questions:

-- What are the land use impacts of alternative methods of financing the local share of interceptor costs?

-- What are the land use implications of alternative EPA financing policies?

Discussion of these two policy issues, found in paragraphs 2.8 and 2.9, completes this policy analysis section of our study report.

2.1 Do Land Use and Population Projections Tend to be Self-Fulfilling?

Population projection is often the most controversial aspect of facility planning for sewer interceptor construction. Because sewers are ordinarily built with long design lives, the EPA is put in the position of subsidizing future growth of an area, on the basis of questionable population projection statistics. The question of interest here is not whether such future populations will be reached or not, but whether they will be artificially induced because of the presence of new interceptors designed with capacity in excess of that required by reasonable population growth trends.

Population growth in the areas studied can be seen as the summation of the following four factors:

(1) Natural growth, the excess of births over deaths in the project service area.

(2) The share of regional in-migration to the project service area expected on a pro-rata basis.

(3) The extra share of regional in-migration the project service area may receive because of special amenities it may possess (including sewers).

(4) Growth due to intra-regional migration to the project service area because of special amenities.

In calculating the first factor of growth, the recent drop in the birth rate nationwide was not considered in population projections made for the projects included in our study. However, it is clear that the birth rate in suburban areas has dropped significantly. In the Tulsa Metropolitan Region, for example, the average number per household has dropped from 3.2 to 2.8. This is a trend which gives every appearance of being long-lived, not just a temporary phenomenon. Though birth rate is not a major factor in the growth of newly suburbanizing areas (compared with in-migration), it should at least be carefully considered in making long-term population projections.

In-migration is affected by two factors, natural population growth in the country overall, and employment growth in the study area. Surprisingly, little or no attention is focused in population projections upon the declining national birth rate. Most attention is given to the notoriously volatile employment growth rate. The drop in the national birth rate, assuming that it continues, has two effects on in-migration to an area. The direct effect is, of course, the diminution of the pool from which growth can be drawn. The indirect effect is that the smaller families migrating to an area require a greater number of jobs to support their decision to move. Women, having fewer children, are freer to work, and are seeking jobs, and it will require a proportionately greater growth in employment to attract families to an area than it has in the past. Therefore, population projections which depend on present growth trends in the area's employment may have to be revised downward. Even if the employment increase does continue as expected, it will support a decreasing number of households in the future.

It is possible to anticipate the third factor, the larger share of the new population that will be attracted to a newly opened area because of its modern amenities, but it is difficult to quantify it. It is harder to anticipate the fourth factor in an area's growth: intra-regional migration. Large SMSA's are familiar with this phenomenon, as the middle class moves away from the problems of the central city. It also occurs, however, in much smaller and newer communities, which do not suffer from the same diseases as do the old metropolitan areas. In the Tulsa Metropolitan Region, an extreme example of this, growth within the project service area exceeds 100% of the total growth of the metropolitan region: estimates have put it as high as 200%. Housing in other parts of the city is being abandoned by families who want to escape older areas and move to the newest suburbs, and who cannot find buyers for their houses. The only visible reason for this is the gradual change in the racial make-up of the older areas. The housing is still sound, but the people want to move away for purely "social" reasons. The value of their houses is low because there are no buyers, so the loss to them is not much worse if the houses are simply abandoned, which they are.

In the majority of the case study projects, study staff found evidence of great uncertainty in the population forecasts. In each case where uncertainty existed, the population statistics ultimately used in sizing the interceptors were very high projections--far in excess of past growth or growth trends for similar areas. For example, in North Fulton County, Georgia, the engineer predicted levels of population well in excess of those by the regional planning agency. Opponents of the EPA project feel that the engineer's projections may well be borne out, but only because county officials and developers are encouraging it by putting in projects such as the sewers. The land use planning agency, though it questioned the population projections made, and could foresee problems if these figures were induced, was unsuccessful in attempts to reduce the population estimates made by the engineers.

In the Horn Lake Creek/Southaven, Tennessee, project there is a feeling of inevitability for the prospects for growth, but the projected figures used in sizing the interceptor were over ten times the current population, and based upon an exceptionally high rate of growth already decreasing. However, this high projection for population increase may be realized by the mode in which the capital costs of the project are to be paid off: connection fees will finance the project, and there will be a great incentive to permit any and all new development. Without the projected population, the county will place itself in debt.

In Staten Island, New York, population forecasts were based on sketchy evidence--the zoning regulations of Richmond County. Under current economic conditions, housing starts have slowed down, making it unlikely that zoned densities, which are rarely met in practice, will even be approached. Past history in the area sheds further doubt on the projections. Staten Island's first building boom occurred in the twenties, when a new subway connection was proposed to link the community with Manhattan. This never materialized, and the growth stopped short. When the Verrazano-Narrows Bridge finally did link the island with the rest of the City, another boom began, but has recently slowed substantially. On the other hand, there is the possibility that a radically new type of development, a high density new town project which has been proposed, could yield population increases in excess of that predicted. However, these uncertainties have had no major impact on the plan for sewer interceptor construction; neither the slowing present pace of growth nor the ambitious new proposals are evaluated in the plan.

In cases where population increases are uncertain and widely varying estimates are made, it is common to find a fictitious middle ground level of population increase accepted as probable, no matter how irrational that choice may be. In rapidly growing areas, engineers often base their projections on evidence that is really speculation. They sense that there is a strong potential market for housing, and find, once the sewer interceptor project is announced, that land prices go up, subdivision applications increase and speculation begins. A circular and self-fulfilling process of growth occurs, in which the engineer, the county officials, and the regional planning commission may not be entirely disinterested.

In response to this, the land use planning agencies find themselves in the position of having to interfere with the behavior of the private market. They often do not wish to attempt this, for reasons which range from the philosophical to the practical. Usually, they are powerless to intervene even if they want to and may decide, as in the Tulsa region, to create similar incentives to growth in other regions to draw off pressure from the first region. This may spread the housing market too thin, over-extend the bonding power of the community to provide services, and lead to disorder and financial problems.

In summary, population forecasting in the study projects was found to be extremely speculative. On the one hand, there are pressures to fulfill initial population estimates, even if they are unreasonable, and on the other, there is the prospect of a declining pool of population nationwide from which to draw new population. By the year 2000, if present trends persist, natural population increase in the United States will be almost negligible. It would be good policy to order applicants to specify the source of their population projections, the assumptions on which they were made, and the behavior of the population growth within the region of which the service area is a part. If significantly different projections have been made by other bodies, they should be included in the application. EPA should review the population statistics to decide if they are responsibly derived, and should agree to a stated policy for funding reserve capacity (see Section 2.9).

2.2 Is the Standard Per Capita Water Use Formula Employed in Siting Interceptors Creating Unnecessary Excess Capacity?

At present, EPA frequently encourages engineers to design interceptor and sewage treatment facilities based on a standard water use figure of 100 gallons per capita per day (gpcd). In a recent need survey performed in Region IV, this standard was raised to 125 gpcd for tentative sizing of treatment plant capacity. Though there is no consensus among engineers on a standard per capita water use measure for interceptor sizing, most agree that the 100 gpcd figure is generous. In almost all project areas, the engineers believed the 100 gpcd standard was higher than actual per capita water consumption, and in rural areas, the actual consumption is often documented at half that figure. Since EPA also frequently encourages interceptor design based on a ratio of peak flow to average flow sufficiently high to provide a large margin for error in pipe sizing, we would question the current practice of utilizing a standard measure which generally overestimates per capita sewage flow. The overgenerous design of interceptor sewers may represent a significant waste of scarce federal resources. From our analysis of economies of scale, it appears that direct facility savings of from 5% to 30% could be realized using the actual rather than standard figure for water use.[1] Second, this practice allows more population than anticipated to connect to the interceptor. Third, the 100 gpcd figure provides an incentive for some engineers to perform only superficial infiltration/inflow analyses. Feeling that there was considerable leeway in the pipes already, due to the high standard water use measure, several engineers stated the view that accurate calculation of infiltration/inflow rates was unnecessary.

Furthermore, standard justifications for a generous design standard are of at least questionable validity. The EPA figure is based on the assumption that per capita water use will rise in the future as real disposable income rises. However, there is evidence that this may not occur. Many households, of even moderate income, have all the water-using appliances that they can use: a dishwasher, clothes washer, and garbage disposal. Since sanitary water use is independent of the number of bathrooms available to a family, this will not increase with income. The only water uses which exhibit income elasticity to a significant extent are not related to sewage flows. Lot size is correlated with income, and lawn irrigation does not enter the sanitary sewers, nor does water from swimming pools, another high income luxury. And, as mentioned previously, the high peak/average flow ratios now employed--varying from 1.5/1 to 3.5/1 do provide a generous safety factor if actual water consumption rates are underestimated.

Finally, it was suggested by some planners that EPA concentrate on policies which would effect a net decrease in per capita use of water, rather than plan for further increases in the per capita use. At the very least, a more rigorous examination of actual community needs across the country would be useful. While there are economies of scale in sewer construction, additional capacity is definitely not free. A certain level of conservatism is wise, but there ought to be an analysis of the cost effectiveness of setting nationwide standards for per capita water use.

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1. This is based on the regression analysis carried out in Section 4. The scale factor of 0.5 derived from our data and corroborated by other studies implies that if one designs for 100 gpcd and actual use is 44 gpcd (lowest found in study), then one could save 33% by building to the lower figure; if actual use is 90 gpcd, then the savings would be about 5%.

2.3 Should Design Life Periods for Interceptor Construction Be Reduced?

In the design of interceptors, it is well accepted that the most cost effective, and therefore most sensible, approach is to size and install interceptors for a design year population equal to the physical life of the sewer pipe. Though engineers express the estimated physical life of the interceptors as a fifty-year period and then calculate a fifty-year population projection to use as a basis for sizing the pipe, in practice pipes are left in service almost indefinitely, and the fifty-year population statistic is derived by estimating the ultimate population of the interceptor service area. This practice is considered most economical, for it takes full advantage of the economies of scale in interceptor construction and there appears to be no danger that sewer construction will suffer technological obsolescence. It is also also assumed, correctly, that the costs of building replacement or parallel sewers will increase as the service area develops.

The results of our study suggest, however, that the accepted practice of sizing interceptors for the ultimate population of a service area may not be the most desirable course for EPA to pursue. Our analysis of this issue is a preliminary one, but we feel that two questions related to design year periods have not been given adequate considerations: Are there significant factors other than dollar costs of construction that would argue against fifty-year design periods? Just how great and how predictable are the cost savings involved in sizing interceptors for ultimate population? In this issue paper, we would like to explore both of these questions. As the public has become more concerned over the quality of their living environment, there has been increased pressure for stricter controls after land use in residential areas. In response to this pressure, it has been suggested that provision of essential services--including highways, water supply and sewer services--could be used to control rapid and unplanned development. Sizing interceptors for shorter design periods, while more expensive, would provide this type of land use control--communities could phase in new development by staging available sewer capacity. "No connection" orders can be issued, effectively preventing new housing construction. In Ramapo, New York, a court decision allowed the community to do this--to phase in its utilities and service facilities gradually over an eighteen-year period, thus forcing construction of new housing to follow, rather than preceed, the ability of the town to service it.

Our study reaches the tentative conclusion that, not only might reduced design life be advantageous as a land use control, but that such design periods may actually be more economical than the conventional fifty-year standard. The key to the analysis, which is presently in detail in Section 4, is the concept of the present value of the investment in future capacity. Two equations are compared. The first calculates the cost of building a pipe for a population fifty years in the future, including consideration of economies of scale and assuming a straight line growth pattern. The second calculates the total cost of two pipes, the first to serve the population estimated in twenty-five years, with consideration of economies of scale, and the second to serve the additional population expected to arrive between the twenty-fifth and the fiftieth years, also with consideration of economies of scale and discounted back to present value at a rate of 6% per annum. The second equation also includes consideration of penalty costs to be expected when one goes into a developed area to lay additional pipe.

The conclusions are interesting. It appears cheaper to lay pipes in two phases if the penalty factor is 1.0; and at higher interest rates of 8% two-stage phasing is superior, at growth rates over 3%, even assuming higher penalty costs. (see Section 4, Figure 8)

An 8% rate is quite reasonable in 1974, but may be high over the twenty-five-year period. A penalty factor of 2.0 is conservative, we feel, since the developed areas we are studying are built up in a comparatively low density of suburbanization. Central city penalty costs may be higher than 2.0, but in all likelihood, in the suburbs the penalty factor is less than 2.0.

This analysis alone gives weight to the argument that long staging periods may represent little real saving in developing areas. In areas where the growth rate is very high, the fifty-year design period appears to be more expensive than a twenty-five-year one. In most cases, the two costs are so close that the saving for a fifty-year design period is negligible. In order to gain some leverage over land use, it seems logical that EPA might reject the "cost-effectiveness" argument supporting the fifty-year design period. One project engineer said, "It costs nothing to use a bigger pipe." However, our study does not support this statement.

When one considers the speculative nature of the fifty-year population projections, the argument for shorter design periods is stronger. If populations projected are not reached, or are not reached by the year expected, this effectively reduces the savings to be expected from building for ultimate population. Although some of the projects have an implied year to design of less than twenty-five years, many have extremely long implied design years--the highest being several hundred years (Ardmore's 2,360 year design period is rather remarkable).

Our "implied design year" represents the general growth rate in the region over the last two census periods, and does not take into account the special circumstances which have provoked growth in a certain area, such as the presence of a new industry. However, the implied design year does put a specific project in contrast with region-wide residential trends, and gives a different perspective to the validity of fifty-year, or "ultimate," population levels. Where the implied design year is vastly greater than the engineer's design year, the implied year should probably be ignored. Where the implied year is fifty or one hundred years different, then one may wonder about the validity of the engineer's projection. Is there really any feature of the project area which makes it so much more desirable for development than the rest of the region, or is there simply an anticipation that the project will induce excess growth?

If our tentative conclusion is borne out that reduced staging times for projects in suburban areas represent little or no financial penalty, more reliable planning could be the result, and Federal funds could be spent more efficiently.

2.4 Do Land Use Planning Agencies Play a Useful Role in Interceptor Planning and Review?

In response to questions concerning the land use implications of the proposed EPA interceptors, EPA regional office staff, almost without exception maintain that the land use planning aspects of the projects are left to state and local agencies to study, to review and to resolve. Given this attitude, it is important to ask what role the land use planning agencies now play in the development of sewer project plans prior to EPA award of federal support for the construction of interceptors. Are these agencies prepared to provide project planners with considered land use and population projections which reflect the development they anticipate and desire for the interceptor service area? Have these agencies studied the possible impact that interceptor construction may have on the established land use plans or development trends? Have staff members from these agencies carefully reviewed the EPA project plans prior to submission to the regional offices? Has the involvement of the planning agencies had any effect on the design or the staging of the proposed project?

Based on our case studies and reviews of other EPA project files, it is clear that the land use planning agencies are not actively involved in EPA project planning, and the answer to all of the above questions is "no." The local and metropolitan area planning agencies have generally developed land use and population projections for their planning areas, and the consulting engineers on the sewer projects do use this information in preparing their own, often independently developed, estimates for design year and ultimate land use and population for the service area. However, the projections made by the planning agencies rarely reflect a land use or population forecast which is viewed as an enforcible plan for desired development of the area. Rather, most planning agencies take the stance explicitly stated by the Fulton County Planning Commission: that the land use plans are only "guides," that they are expected to change as actual development occurs, that they are accurate only for a limited period of time.

This lack of sophisticated land use planning was certainly not an unexpected finding, for land use planning agencies have seldom been given the tools to exert controls over the process of development. Rather, they are encouraged to serve the needs of developers active in their planning areas. The majority of planning agencies respond by concentrating their efforts on keeping one step ahead of plans for development, and do not critically examine alternatives to existing development trends.

Consistent with this general pattern of planning activity, the vast majority of planning agencies operating in the case study areas had never studied the possible adverse secondary impacts of rapid development within the service areas of the proposed interceptors. When questioned about potential problems of service provision to in-coming residents, traffic congestion, air pollution, and other consequences of unplanned urban sprawl development, many agency staff appeared never to have considered these issues, while others viewed the possible problems as the inevitable problems of any future development. Only two of the many planning agencies that had knowledge of these projects--one in Fulton County, Georgia and one in Oakwood Beach, New York--raised questions concerning the stimulus effect of the interceptor construction on development, and the negative impact which might be created by the increased rates of development. In both cases, however, the issues raised were not explored in depth, and the projects were approved as initially proposed.

In general, the official A-95 review was a pro-forma procedure involving no serious study of the relationship between the sewer project and other regional plans or activities. However, the ineffectiveness of this review procedure is illustrated best by the cases mentioned above, where planning agencies did question the adverse secondary impacts the projects might have. In Staten Island, one of the planning agencies contacted by the A-95 agency recommended that the project be staged to avoid immediate opening of undeveloped land by the construction of a planned interceptor. Though their letter making this recommendation was attached to official A-95 review document, the official A-95 agency approved the project without any mention of this objection to the proposed plans. The A-95 reveiw conducted in Fulton County, Georgia, also highlights the futility of the review process. Immediately after the release of a draft EIS approving the proposed North Fulton County EPA projects, the A-95 agency wrote a strong letter questioning the lack of attention given to the potential adverse secondary impacts of the project. The agency recommended that further study be given this issue, and that the interceptors definitely be sized for a twenty year, rather than an ultimate, population. However, project funds--already committed prior to the preparation of the EIS--were released to the county without any further study of secondary impacts and plans to size the interceptors for ultimate population densities were approved. This lack of impact was consistent across all of the projects studied: in not one project was any substantial change made in proposed interceptor plans as a result of local or regional planning agency input into the planning process.

The present review processes, including the A-95 review, appear to afford local planning agencies little opportunity to influence the design of most sewer interceptor projects. At present, their only influence is in providing engineers with preliminary land use data and population figures. They could play a more important role if their expertise were brought in earlier in the design of the projects. Under Sections 201 and 208 of PL 92-500, they ought to be more involved in region-wide planning. At present they are brought in too late in the planning process to make a significant contribution; their advice is often ignored if it contradicts the opinions of the sponsoring groups. If the planning agencies submit population figures at variance with those of the engineers, there would be opportunity to reconcile differences. If nothing else, there could be coordination of projections for other facilities needed to support anticipated growth, such as schools, roads, and other utilities.

2.5 Does the Environmental Impact Review Procedure Deal Effectively with Land Use Impacts?

Federal law requires that a careful analysis of possible adverse environmental impacts be performed before Federal funds or approval is granted to any project even for pollution control projects whose basic purpose is improvement of the environment. However, for the projects examined in the present study, adverse environmental impacts which might occur because of residential development resulting from the availability of sewerage services were generally ignored. There are several possible explanations for the failure to consider these secondary land use effects:

(1) The basic purpose of the projects is water pollution control and EPA seeks to implement that with the minimum of delay.

(2) The EPA feels that land use planning is specifically outside its area of responsibility.

(3) The adverse secondary impacts these projects engender have actually not been perceived, or have been ignored.

It is natural to seek to avoid the expensive and time-consuming preparation of a full Environmental Impact Statement. Development in some areas is continuing at a pace which demands the fastest possible installation of water treatment facilities. Yet the ultimate impact of these facilities on development patterns is great enough as to warrant the most careful evaluation of their effects. The dilemma of the EPA in feeling that it is being wrongly called upon to make land use policy decisions appears to us to be no reason to avoid evaluation and discussion of the secondary impacts of the projects, and some effort to minimize these impacts in the planning process.

The stance taken by EPA offices is illustrated in the EIS prepared on the North Fulton County interceptor projects, where the question of secondary impacts is raised:

> The EPA does not have the authority to limit land development, dictate the type of land developments, of require ordinances relating to soil erosion/sedimentation/siltation. The mitigating measures of land use control and public services must be provided by the local governments. The EPA realizes that sewers can support development and that some adverse effects can occur... In spite of the possible adverse effects and difficulty in calculating these effects, EPA will propose to approve some projects.[1]

The statement goes on to state that developers would otherwise provide their own facilities, so great is the demand for them, but that the project which the EPA is prepared to fund will be superior in water treatment effectiveness to the privately constructed facilities. Thus, the benefits outweigh the potential damage of secondary effects. Though this North Fulton County EIS is superior to most of the statements prepared for these projects, it does not consider possible actions that EPA might take short of refusing to fund the project, and it minimizes the extent to which federal monies are being committed to support development that may harm the environment.

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[1] Final Environmental Impact Statement: North Fulton County, Georgia, WPC-GA. 189 and Northeast Cobb County, Georgia WPC-GA. 173. United States Environmental Protection Agency, Region IV, January 1974, pp. 60-61.

However, the Ocean County, New Jersey EIS confronts this issue more directly when it quotes the New Jersey Department of State and Regional Planning in the following evaluation of the secondary effects of these projects:

> It seems that Ocean County would develop rapidly even if the regional sewer system weren't built. However, pollution problems are beginning to plague various parts of the County. Developers are willing to build package treatment plants, but not whole collector systems and tertiary treatment plants with ocean outfalls. The regional sewerage system, thus, will be another factor in insuring continued growth, removing one of the few obstacles which can be seen today to rapid growth.[2]

The conclusion of the EIS and its recommendations assess this fact.

> State and local land use legislation cannot prevent urbanization of the communities in the Central service area. At most, existing legislation can retard the rate of urbanization and can promote the orderly implementation of development.[3]

> The Ocean County Planning Board, the municipal planning board for each community in the Central Service area, and the Ocean County Sewerage Authority should jointly decide on a land use strategy that will prevent contravention of the Clean Air Act.[4]

This Impact Statement is one of the few which relates air quality degradation to the installation of water pollution control facilities through secondary effects. This is most important as a precedent for future Environmental Impact Statements. While the statement recognizes the immense difficulty of land use planning, it does not shrink from the implications of the proposed project, but seeks to discover what discretion exists within the scope of EPA's mission to provide water treatment that could lead to more environmentally sound development. For instance,

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[2] Environmental Impact Statement on a Wastewater Treatment Facilities Construction Grant for the Central Service Area of the Ocean County Sewerage Authority in Ocean County, New Jersey, Draft, April 1974. U.S. Environmental Protection Agency, Region II, p. 46

[3] Ibid., p. 160

[4] Ibid., p. 161

> It is not the intent of the U.S. Environmental Protection Agency to restrict the ultimate population of the Central service area to 250,000. However, the U.S. Environmental Protection Agency will not grant funds for the expansion of the Ocean County Central sewage treatment plant beyond 91,000 cu m/day (24 MGD) or issue a discharge permit for the expanded facility if that expanded facility will directly or indirectly cause contravention of the air quality standards.[5]

Unfortunately, neither the Ocean County or Fulton County Environmental Impact Statements are typical of the general quality of environmental analysis done for these projects. Only a handfull of EIS's have been prepared on the projects funded under the construction grants program. EPA regional offices appear to go to lengths to render a declaration of negative assessment. In some cases where tremendous growth is forecast, misleading statements are made by project engineers to support these negative impact declarations:

> So long as this project is delayed, or in the event that it is not constructed, then the present, or then existing, generation must continue to pay an "environmental cost" without gaining any benefits whatsoever.

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[5] Ibid., Footnote 4, p. 159.

> This environmental cost is manifested in restriction of growth and prosperity, limiting land usage to lower orders than would otherwise be possible, and eventual gross pollution of the environment.[6]

However, in most environmental assessments used by EPA to support negative declarations, secondary effects are simply glossed over. There is a tendency to direct the bulk of the environmental assessment to the benefits of controlling pollution or the very temporary negative impacts of construction, such as noise or dust from the actual laying of the sewer pipe. The more difficult questions of land use, which are important in the long run, tend to be disregarded to the extent that it is felt the public will disregard them. Statements such as the one above, from the analysis of the Tulsa/Broken Arrow project, in fact reflect the general public attitude in many areas that residential development of the kind the project will permit is highly desirable; the statement has been tailored to its audience.

Effective land use planning cannot proceed under these conditions. The Environmental Impact assessment process should be used honestly to assess the full impact of suburbanization. Although the interceptor sewers are not in themselves sufficient to control the shape of growth, their environmental impact assessment process provides one of the few good opportunities to increase public awareness of the implications of the growth process.

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[6] Environmental Assessment for Construction of the South Arkansas River Regional Wastewater Facilities, prepared by W. R. Holway and Associates, Inc., and Wheeler Associates, p. 63.

2.6 Is the Public Aware of the Land Use Impacts of Interceptor Construction?

In theory, the agencies and institutions charged with specific responsibility for the planning of EPA sewage treatment programs should encourage and respond to both the needs and the concerns of the general public. Thus, in performing this study, we attempted to determine the extent to which planning of the projects had attracted attention in the communities they are to serve, the response to the projects by individuals not directly involved in project development, and the influence of the public in shaping the plans which were ultimately approved by the EPA.

In general, the proposed EPA projects did not attract a great deal of public attention in their respective communities, particularly during the planning process, prior to the award of the federal grant. Only a limited number of community residents were aware of the plans. They included those individuals involved in residential, commercial and industrial development of the proposed service area, and selected individuals residing in the service area who would be immediately affected--either positively or negatively--by the construction of the sewer lines. Since these segments of the public became involved in the projects for different reasons, and had different levels and types of influence on project planning, each will be discussed separately.

In the vast majority of projects, the most active and most influential segment of the public were those individuals either directly or indirectly involved in efforts to develop the vacant land included within the interceptor service area. Since their development plans often are totally dependent on the availability of sewer lines, these individuals are frequently well represented within the public agencies directly responsible for utilities planning. Though none of the projects studied was solely designed to respond to the needs of these developers, the majority of the case study projects were development-oriented in that plans for new development within the area definitely influenced the routing and the sizing of the interceptor lines. Uniformly, the developers were in favor of the projects and paid close attention to the progress made in project planning.

The direct involvement of area residents was slight and came in two very different forms. In all but one case study project, residents of the service area who expressed personal opinions supported the sewer plans, because they would solve existing pollution problems caused by inadequate septic tanks. In the words of one resident who attended the public hearing on the Staten Island project, the sewering of their neighborhoods would give them an opportunity "to live like human beings." In these projects, residents either did not perceive the possible land use implications of the project, did not object to the opening of new areas for extensive development, or simply felt that this issue was none of their concern. A long-time resident of DeSoto County, where the Horn Lake Creek interceptor will open large tracts of land for moderate income housing development, summarized the public attitude there by stating that the people of Mississippi simply do not feel that what individuals do with the land they own should be the concern of anyone else.

However, in other areas of the country, including Fulton County, Georgia, private citizens are becoming concerned over development trends within their areas, and they are beginning to exert pressure to limit the development taking place. Though the residents of the North Fulton County service area initially became involved in the EPA project because it threatened to destroy the natural rock formations and scenic area immediately adjacent to the Chattahoochie River (a favorite recreational area for river sports enthusiasts) they are now attempting to block construction on the project because they feel it will increase the rate of high density residential development in the area. Although not included in the study sample, projects in New York and Florida have also encountered similar community resistance.

Because only one of the case study projects was opposed by residents of the service area, it is impossible to attempt an assessment of the factors which might lead members of the general public to oppose sewer plans with significant future land use impacts. However, it should be noted that in Fulton County, only those residents of relatively high income suburbs have been actively involved in the sewage treatment planning process, and individual residents of the lower income areas who will be affected by other EPA projects have yet to either support or oppose the plans. Furthermore, it appears that the two other EPA projects which have been opposed by area residents (in New York and Florida) also involve plans for sewer construction in affluent sections of the community.

In general, the findings concerning public participation suggest that EPA should undertake further efforts to publicize the project plans and to solicit a broader spectrum of public opinion. Though selected groups and individuals do influence the planning process and are aware of project impacts, public participation rarely focuses on issues that should be of major concern to community residents--the large commitment of public funds, the direct impact of interceptor sizing, routing and financing methods on development, and the secondary effects of development on current land use patterns, environmental quality and the future provision of public services.

Though the public has shown minimal interest in these issues to date, it is not unrealistic to assume that individual residents are unaware of the implications of EPA sewer projects. At a minimum, EPA should attempt to increase the level of public awareness--through newspaper publicity, educational programs, and conspicuous notice of public hearings--and determine the effect of such efforts on stimulating greater public interest and involvement in project planning.

2.7 Are the Impacts of the Interceptors on Energy Consumption Being Considered in the Planning Review Process?

Low density patterns of residential development generally lead to a greater per capita use of energy. Low density housing patterns require a greater reliance on automobiles, heating and cooling single family houses requires a high level of energy consumption, and the suburban consumer life-style is relatively energy intensive. Since the decision to plan sewers for low density living involves a commitment to an energy intensive life-style, it would be appropriate to incorporate consideration of energy issues in the planning process.

However, no consideration of the indirect impact of the proposed interceptors on energy consumption was present in the evaluation of the projects included in this study. Very infrequently, reference was made to the adverse secondary impacts of low density development, but no quantification of energy use was attempted, and the issue was never a major one in the public forum. Though all these projects were originally reviewed and approved before the winter of 1973-1974, when the nation experienced its first energy shortage, there was no indication given to study staff that future review of the interceptor projects might deal with the problem more explicitly.

The issue most allied in the public mind with newer projects is, naturally, water pollution control. Whereas the energy question is readily associated with highway controversies, because roads directly imply committment to automobiles, it is not associated easily with the pattern of other public services. Some disillusionment with the automobile is finally being felt as costs, congestion, and pollution rise, but no disillusionment with single family housing is apparent.

The single instance of attention paid to energy impacts of sewer construction was in one local area where the A-95 agency has just become interested in assessing the relationship between housing patterns in their area and energy consumption. Though they have yet to study energy consumption implications of the EPA sewer projects they approve, this agency--the Atlanta Regional Commission--does recognize that energy considerations should be a factor in all their A-95 review agencies. At present, however, they have performed only a very preliminary study of this issue.

It would have been quite surprising, of course, to have found any meaningful evaluation of energy use and its relation to various land use development patterns. The issue has, even yet, not been popularly recognized. The public regards the energy shortage as an equity issue rather than a resource problem: small home owners feel they are discriminated against by large corporate interests; they do not feel that the shortage is absolute, or should be allowed to affect the basic pattern of their lives.

It is difficult to imagine what influence the planning of sewers can have to change public attitudes about the priorities of energy consumption. If the problem is analyzed simply with regard to the energy required to build a certain configuration of sewer interceptor, then it is clear that shorter interceptors, with high density development, are the best answer, though specific secondary effects must be considered. It would be our recommendation that the question of energy use be included in the public discussion and review of projects through the environmental impact review process, and every effort made to promote public awareness of this issue.

Though there has been no recognition given to the energy implications of interceptor design which promotes low density housing patterns, energy conservation is an issue with engineers and planners as it directly affects the design of sewage collection and treatment systems. The energy required to run lift and pump stations is a direct operating expense which they seek to minimize. Large treatment plants have an economy of scale of energy use as well as of capital expenditure; package plants are very inefficient users of energy compared with large treatment plants, a strong argument in favor of regionalization. A trade-off must be made, however, in regions where pumping stations are required for regionalization, there being insufficient relief for long distance gravity flow. In coastal regions, where infiltration and a high water table severely restrict the practical depth at which gravity lines may be laid, the problem is at its worst.

Given these trade-offs and in the absence of other considerations, it may be desirable to build several small plants rather than a large regional plant. In St. Bernard Parish, Louisiana, however, regionalization, despite the energy costs of long distance pumping, is preferable in the long term in order to remove the discharge of the plant as far from sensitive shellfish beds as possible. As energy increases in cost, the engineers will make the appropriate changes in the design to minimize operating expenses. It would seem useful to insist that the designs of systems be based on the assumption of continuously increasing energy costs, but this might also tend to reinforce the "cost effectiveness" rationale for installing large reserve capacity. The real dimensions of the energy issue are not clear enough to attempt any general policy recommendations at this point.

2.8 What are the Land Use Impacts of Alternate Methods of Financing the Local Share of Interceptor Costs?

It has generally been considered more equitable to place the capital burden of the excess capacity of a system on future users rather than on present users. Many areas prefer to levy a connection charge upon future residents to pay a pro-rated share of the excess capacity.

There is an important side effect of this type of financing: the pressure it puts on the locality to reach its projected population level. Without new connections, the bonds the area has sold cannot be paid off. The sponsors of Haikey Creek Interceptor System in Tulsa, Oklahoma, financed their system by selling developers debentures which could later be applied only against connection fees, and were not convertible into cash. This places great pressure on developers to sell lots as quickly as possible after the system has been installed. Although the debentures appreciate at 6% per year toward the connection fees, there is every incentive to use them as soon as possible. If they are held long enough to appreciate beyond the value of the connection fee, the balance cannot be realized cash. Also, with contemporary interest rates on commercial paper as much as double the 6% offered by the debentures, they are a relatively poor investment for the developers.

In Horn Lake Creek and Southaven, where the financing of the local share is also dependent on development, new housing construction is already beginning to fall short of expectations, and the financing scheme is creating problems. The Horn Lake Creek Interceptor Sewer District had previously agreed to pay a minimum sewage treatment charge to the City of Memphis, regardless of the flow during the initial years. The recent fall in housing sales has shaken their confidence in this decision, and they are now negotiating for a lower minimum payment or no minimum at all. Though they had been willing to rely on new development to create the minimum necessary flows, they would now like to pay only for the flows actually processed. Another problem has arisen in these two Mississippi projects. Developers had agreed to pay a $100 per lot fee to defray the costs of the new sewer, and the local sewer district used these promises to support their application for a low interest FHA loan to finance 50% of the local costs. However, FHA has resisted this financing scheme--the agency is in favor of repayment based on a "no growth" policy, in which amortization of the capital cost is not dependent on new connections.

Projects which do not require future residents to pay their share of the sewer capacity are generally considered less equitable, but they have the advantage of escaping the necessity to fulfill their population projections. Such a project is St. Bernard Parish Sewer District #2. There, the local share of the project comes out of the sales tax revenue of the Parish. Past and present residents are paying for facilities from which future residents will benefit. Future residents are not paying the marginal costs they impose on the community, and the town will give windfall benefits to landowners whose property is not now sewered, making it more likely that presently agricultural land will be converted to residential use.

In principle, forcing present residents to pay for future growth can yield greater community control of growth. In Fairfax County, Virginia, voters actually defeated a bond issue for a new sewer interceptor because they wanted to reject the growth which it would induce. Although the financing scheme was different, the same discretion could have been exercised in St. Bernard Parish, had the voters been aware of the money being spent in their name, and had they objected to that policy.

Similarly, in New York City, there has been no front footage assessment on property owners to finance sewage treatment since 1962. Funds come out of general city tax revenue, and there are no connection or user charges. While this appears to be a windfall for developers, it has its drawbacks: other demands on city money are great and sewer construction must be justified to compete for limited resources. While there are demonstrated inequities in paying for sewers out of general funds, the case studies clearly show that a vicious circle is set up if sewers are sited on the basis of the speculation in land which they themselves have induced, and then are dependent for financing on having that speculation come to fruition in development.

2.9 What are the Land Use Implications of Alternative EPA Interceptor Financing Policies?

It is apparent from the case studies that the manner in which projects are financed by the EPA has a significant effect upon future land use. The present policy of subsidizing 75% of all costs of eligible interceptors and collection systems is basically an extension of the 75% subsidy of treatment plants which was previously in effect. We see at least three basic alternatives to the present funding scheme.

- To withhold funds for interceptor construction entirely,
- To change the grant formula, and
- To limit or curtail funding of reserve capacity.

(1) Withholding funds is the most obvious method of influencing land use, and would mean a return to the original practice. The entire burden of providing line work would again fall on the locality, and they might be more realistic in their design of interceptors if they must assume the complete costs. Since the treatment plant would still receive funding, it could be built to receive whatever flow would come from the amount of linework the community decided to finance. Economies of scale in the treatment plant would not be lost, since EPA has recently followed a policy of designing plants for efficient modular expansion. However, this financing scheme has definite

disadvantages. Economies of scale in the interceptor would be lost if communities chose not to build for reasonable future growth. (The inefficiency might be great--see paragraph 3.2.5 on interceptor staging.) Furthermore, it could easily lead to decreased regionalization, an avowed objective of the present grant program. Many small treatment plants would be built where effective coordination over a large area would lead to significantly greater improvements in stream quality.

(2) Changing the grant formula to something other than a 75% federal subsidy is a variation of (1). A community might be disinclined to buy extensive reserve capacity if its dollars were more expensive, but it would be more likely to build adequate capacity than if it had no available funding whatever, as in alternative (1). The matching grant has the virtue of being an efficient tool for directing public expenditures to socially worthwile goals, but it must be tuned to yield just the right amount of stimulus, not too much. A 50% or 33% matching grant might yield better planning than a 75% grant.

The disadvantage of this approach is that it would have no effect on the configuration of the interceptors. No matter what amount of vacant land is sewered, the government would still be obliged to pay a certain share.

The best solution would be one which affects both the configuration of the excess capacity built, as well as the extent of excess capacity built.

(3) EPA could limit reserve capacity in a system to some specific fraction of the initial flow. Already, such a limitation applies to the funding of collection systems.[1] EPA has attempted at various times to come up with a policy of fixing the permissible amount of excess capacity, but the pressures of the individual situations have defeated their effort.

For example, in Tulsa, Oklahoma, a very large amount of excess capacity was funded despite strong EPA reservations because, given the local situation, it was the most cost-efficient thing to do. In Ocean County, New Jersey, an upper population limit was tentatively set, but it was done on the basis of the possible violation of the air pollution standards through secondary effects of development.[2]

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[1] Federal Register, Volume 39, No. 29, February 11, 1974, § 35.925-13: "No award may be made for a new sewer system in a community in existence on October 18, 1972 unless...the bulk (generally two-thirds) of the flow design capacity will be for waste waters originating from the community... in existence on October 18, 1974."

[2] Draft Environmental Impact Statement; Ocean County, New Jersey, p. 59: "It is not the intent of the U.S. Environmental Protection Agency to restrict the ultimate population of the Central Service Area to 250,000. However, the U.S. Environmental Protection Agency will not grant funds for the expansion of the Ocean County Central sewage treatment plant beyond 91,000 cu. m./day (24 MGD) or issue a discharge permit for the expanded facility if that expanded facility will directly or indirectly cause contravention of the air quality standards."

Neither of these instances of EPA action have yielded a good general policy for funding excess capacity. What is needed is a funding program which leaves flexibility for land use planning on the local level, yet does not put EPA into the position of funding unnecessarily large projects.

The most promising alternative appears to be a variation of alternative (3): EPA could finance, at the present 75% rate, sewers for the existing population only. If a community were to be adequately served by a fifteen-inch pipe one mile long, for example, the grant would cover only that. Additional capacity, either in diameter of pipe or in additional length, would be financed entirely by the community.

As a result of this policy, communities would have a direct incentive to develop land to a higher density. Since economies of scale are quite substantial in the laying of pipe (see Section 4.2.2 through 4.2.4), it would be advantageous to provide excess capacity within the area presently occupied. To open up vacant land, a community would have to bear the full cost of lengthening the pipes. As local financing has always been the practice in the past, this is not an unreasonable burden.

Furthermore, by financing existing population only, EPA would save considerable money which could be used to finance additional projects. Thus, agency funds would have a greater overall impact on stream quality, and EPA would not be put in the position of passing judgment upon land use policy in a local area. If local planning bodies are brought into the planning process earlier, as recommended previously, a much more reasonable and coordinated pattern of development could result.

Regionalization could still be effected through the requirements of Step 1, Facility Planning, an option which would be lost if funding for all sewers were totally cut off. Though there would be a tendency for the intra-regional connecting lines to open up new land, careful review of the planning process by EPA could minimize this and prevent abuse. This funding scheme would have its defects, but on the basis of the case studies performed and the statistical analysis of the original fifty sites, this option appears to us to have considerable merit and deserves more study.

3. Recommendations for Policy Change

Although USR&E's analysis of the impact of EPA grants for interceptor sewer construction must be considered tentative and preliminary, the striking pattern of common problems shared by almost all the case studies indicates clearly a need to re-evaluate Federal policy. The case studies demonstrate that interceptor construction projects have major land use impacts, in some cases environmentally undesirable effects. These land use implications of interceptor grants are not being considered in the planning and funding process nor are the tools and data to evaluate these impacts being developed.

The six policy recommendations proposed in this section of the report are based on the premise that the Federal government ought not to be subsidizing and encouraging unplanned growth which may have serious environmental consequences. Orderly growth must, of course be provided for, but this must reflect clear and explicit land use policy developed at all levels of government. The recommendations focus on possible changes in U.S. Environmental Protection Agency policies. We hope that they may provide a stimulus for discussion of Federal policy. In addition, some of these recommendations could be implemented by state or local governments.

3.1 Recommendation #1: Do Not Provide Federal Funds for Excess Capacity

At present, the EPA is obliged to fund 75% of all interceptor construction it finds eligible under P.L. 92-500. In our study, we explored how this money for interceptor construction is spent, and discovered that more than half of it is being utilized--perhaps inefficiently, according to our analysis of project design--on sewering vacant land for future population. Standard engineering practice, which has been accepted by EPA in the interest of cost effectiveness, has been to size pipes for ultimate population levels. As a result, government funds are being committed on a large scale to provide for continued suburbanization.

The conclusions of the data analysis are based on the premise that the populations projected will materialize. We have tried to be conservative, and have compared estimated populations with the observed growth rate in project regions. If the populations projected do not arrive when expected, then the lavishness of federal subsidies become outright waste.

We have found that it is very difficult to project ultimate population levels in any community, and that most projections are based upon development of the entire project area to its fullest capacity. We find first, that such population and ultimate flow projections are high (see Section 2.1, and Section 2.2), and that building interceptors for an ultimate population which may not be realized for fifty years or more is not cost-effective in some cases. Furthermore, we have found that adequate information is often not available on the initial flows to be expected when projects are put on line, yet it is this population which we feel ought to be served by government funding--not future population.

Given these findings, it is our recommendation that EPA refuse to fund any excess capacity in the sewer system beyond that necessary to serve the documented, existing population, and the additional population which will live in the area by the time the project is completed. In the past, communities have had to bear the full cost of sewering land, and it is not unreasonable to ask that they take back part of that burden. This course of action will have two immediate effects: it will halt the expenditure of federal funds for the sewering of vacant land, and it will save a great deal of money which can then be committed to funding additional sewer projects which are needed in other towns and cities.

The policy will also have important long term planning effects. From our analysis of the data from the larger sample of fifty project sites, we found that substantial economies of scale exist in the sizing of pipes in interceptor construction. Other studies have obtained analytical results almost identical to our own. For a local community, this means that if it wants to build capacity to serve future population, it will get more for its money if it simply contributes additional funds to enlarge the pipe EPA will subsidize than if it tries to build longer pipes out into vacant land. Not only would the community have to bear the entire costs of the extra length of pipe into the vacant areas, but it would also have to support the cost of enlarging the EPA funded section to receive the additional flow. There would be great incentive to consolidate future development within the existing community or in directly adjoining areas, increasing the overall density of land use, and there would be a tendency to plan conservatively for future growth. Speculative population projections advanced by those who have a direct interest in future development would be treated with more skepticism.

One objection to this proposed change in policy is that insufficient sewer capacity would be built, and regionalization would suffer. Local communities might become to wary to spend their own money, because there would be no matching funds to make the investment more attractive. However, we believe this danger can be avoided. Under Section 201 of

P.L. 92-500, the facility planning stage of the grant procedure, future growth in a service area, must be considered, and possibilities for effective regionalization examined. Monies are not released for the design phase of the project until EPA is satisfied that the overall project is responsibly planned. In effect, though EPA would not fund excess capacity, it could insist that it be built. (This policy was followed in the case of the treatment plant designed for Ocean County, New Jersey. EPA said that it would fund only a 2MGD plant, but would not release funds unless the plant was built to handle 3MGD.)

An important impact of this policy would be to increase the number of areas which could be provided with sewers for the same level of federal funding. At present many serious pollution problem areas with low priorities may wait years to receive funds, because of the enormous costs of providing extra capacity for projects with higher priorities. Restricting funding to current sewerage needs may be a simple method for accelerating the rate of environmental improvement on a national level.

In summary, though not the whole solution to the problem of interceptor construction supporting suburban sprawl patterns, our proposed change in funding would encourage local project sponsors to pay closer attention to the need for, and costs, of development-oriented sewer systems. This funding strategy would also ensure that EPA monies are spent to correct existing pollution problems, the primary objective of the construction grants program. In addition, there would be a net reduction in the support given to the development of large interceptor systems once financing of excess capacity is eliminated, and the money saved could be used to finance other worthy pollution control projects.

3.2 Recommendation #2: Re-evaluate Interceptor Staging of Project Design in Rapidly Growing Areas

Consistent with our first recommendation to stop financing excess capacity, we would recommend a general reduction in the design period of the interceptors built in rapidly suburbanizing areas. This has been considered in the past as a way in which to influence land use in an area, but is usually rejected on the basis of cost-effectiveness. Our preliminary statistical analysis shows that, especially in rapidly growing areas, the ultimate savings represented by a fifty year design period over a twenty-five year design period is negligible. In fact, it appears that the shorter design period can be significantly less expensive in certain circumstances.

It has been customary to plan sewer construction for a design life of fifty years to match the physical life expectancy of the pipe. This requires engineers to calculate fifty-year population projections, which cannot be anything but speculative, and it brings out the engineer's justifiable tendency to err on the safe side of over-design. However, with the limited amount of money available for the Construction Grant Program, we feel that attention should be given to the present value of capacity not intended for use for several decades.

When considering the present value of a system, one must take into account the penalty to be paid when additional capacity is constructed parallel to existing capacity in a developed area. Even so, on the basis of the fifty projects statistically analyzed in this report, it appears that shorter design periods are more cost effective than long ones in many cases.

Some state officials were of the same opinion, feeling that long design periods were only warranted in the most rural areas, where growth is slow and popualtions small, and where excavation is a much greater fraction of total project cost. In rapid growth areas, however, they were of the opinion that long design periods were wasteful of federal funds, as they tend to give more weight to speculative population forecasts and make immediate large scale construction an economic windfall to the community.

Excess capacity, while it is economical, is definitely not free. Capacity never used is no bargain, whatever the price. In order to avoid over-design, and in order to make federal expenditures most cost-effective, we recommend that project design times be reviewed with care in the light of the present value of excess capacity. In rapidly growing areas, the savings represented by long design periods are negligible at best. In such cases, it is in the interest of the federal and local governments to use the staging time of interceptor construction as a brake on the suburbanizing force.

3.3 Recommendation #3: Use Realistic Standards for Per Capita Flow

There is no consensus of opinion within the engineering profession over what standard figure for per capita flow might be used for designing sewers. Actual figures vary from region to region, with rural areas apparently using less water per capita than urban areas. EPA often encourages the use of 100 gallons per capita per day (gpcd) as a standard figure, even when actual use has been half of that. Their rationale has been that water use will go up in the future, as incomes rise. We prefer to side with those who would employ the actual use figures in sizing interceptors and would recommend designing each system on the basis of proven water usage in the particular project service area.

There is no evidence that per capita water use will increase markedly in the future. Since a great many households of moderate income own all of the basic water using appliances--dishwashers, clothes washers, and garbage disposals--there is no evidence that per capita sewage production will increase substantially as income increases. The discretionary uses of water which are correlated to higher incomes--lawn irrigation, and swimming pool use--do not contribute to flow in the sanitary sewers. Furthermore, adequate safety factors are always included in sewer design. Peak to average ratios of 2.5:1 are common. Even if comparatively low per capita flow figures are used, this safety factor can protect against flows higher than anticipated.

There is an additional factor to consider, which was raised by individuals interviewed during the course of our study. Knowing that provision of clean water in sufficient quantity is becoming more of a problem nationwide, several engineers and state water pollution control personnel felt it would be better policy for EPA to coordinate water supply and sewage treatment programs to miminize future per capita water use. However, recent need surveys conducted under EPA auspices have been directed to use 125 gpcd as an estimating figure. It was felt that such a high figure was not justified and that it was counter-productive in terms of anticipated water supply problems.

3.4 Recommendation #4: Improve Population Forecasting Techniques and Review Procedures

Even if design periods are reduced to a more manageable twenty-five years and communities are given financial disincentives to plan extensive reserve capacity, EPA should still seek procedural methods by which to improve the quality of population forecasting. Twenty-five year forecasts of population are often as speculative as fifty year projections. Various influences on the process, examined elsewhere in this report (See Section 2.1), generally result in projections which are unjustifiably high. While the elimination of funding for future growth may go far to reduce speculative population forecasts which serve the interests of developers, better documentation of population forecasting should be required in the grant application submitted by a community. Local money will be wasted if future population do not materialize when expected, and even if they ultimately do arrive, the money could be better spent elsewhere in the meantime.

We recommend that all population forecasts submitted in a grant application be justified by reference to their sources and methodologies, and that all local agencies which have developed their own forecasts be asked to submit them. This would include local and regional planning agencies, but may also include private groups. For example, some of the most realistic population projections are made by telephone companies, electric utilities and similar private service enterprises. If such sources of population forecasts exist, EPA might require submission of this data to support the project estimates.

If all the competing population projections had to be assembled for purposes of the grant application, a useful side effect would be the consolidation of these projections into one consensus of opinion. Local agencies which must provide supporting services for expected growth would be able to contribute their own planning recommendations and possibly influence the growth policy of the area more than they presently can.

3.5 Recommendation #5: Require Consideration of Environmental Effects of Interceptor-Induced Land Use

In most of the projects studied, the assessment of the environmental impact of the interceptors was inadequate. In only a few instances were Environmental Impact Statements prepared--in the vast majority of projects a negative declaration was made on the basis of a superficial environmental impact assessment prepared by project engineers. In most cases, the engineers disregarded all secondary land use effects in this assessment in order to enable EPA to render a negative declaration of environmental impact. Even in those few instances where EPA prepared an Environmental Impact Statement, adverse secondary impacts were given scant consideration, and appeared to have no influence over EPA's decision to fund the project. (The EIS performed on certain Ocean County interceptors was unique in its careful consideration of land use implications. See Section 2.5.)

Whereas this cursory environmental impact assessment may be justified in the case of a sewage treatment plant, whose purpose is to clean up the waters of a stream and thus has a beneficial influence on the environment, it is impossible to assert that land development is without environmental impact or has negligible environmental impact. Therefore, all projects which involve the opening of vacant land for development should be required to submit an assessment of impact which includes full consideration of secondary effects of growth. For projects above a certain size (which could be determined by EPA staff) the Regional Offices should prepare Environmental Impact Statements, in full conformity with Federal guidelines.

While this policy would be more time consuming and expensive than current practices, we feel that EPA is not presently fulfilling its technical responsibilities for environmental protection and that the public has not been adequately apprised of the full effects of the interceptor sewers. It has been led to believe that interceptor construction is totally beneficial which may be part of the reason so few people have become involved in the public debate of the projects.

3.6 Recommendation #6: Increase Public Participation in the Planning Process by Publicizing Community Costs and Benefits of Interceptor-Induced Growth

Though this report has not dealt with the public service costs which residential growth of an area entails, these should be of the utmost interest to local citizens. If the interceptors are allowed to induce excess growth, then they also induce excess costs for providing more police and fire protection for new housing, more roads and storm sewers, more schools and hospitals, and more civic and recreational facilities. Since we are recommending that all costs for sewering future population should be borne by the local community, there is all the more reason that citizens be fully informed about the implications of projects. They should have the chance to influence the design process in something other than a pro forma way.

To this end we recommend that the mechanism by which the public is made aware of EPA project plans be improved. Local sponsors should be encouraged to publicize the project during early stages of project planning. The award of the facilities planning grant provides a good opportunity to do this--with press releases and interviews of individuals involved. It is also essential that the public hearing process be better used to inform the public of sewer plans. EPA should require that notices of the hearing be more prominent in local newspapers, and perhaps carried by the broadcast media as well. To fully inform the public on the impact of sewer plans, these notices should contain the following information in addition to what they now carry:

1. The expected cost of the project to the community in the form of taxes and user charges.
2. The population growth of the community which is projected in the grant application.
3. The amount and location of vacant land which the project will service.
4. The expected additional services which the taxpayers will have to pay for to support the expected growth.

If this is done, and adequate environmental impact assessments are made available at the public meetings, the public will be given a meaningful opportunity to participate in the design and review process. Whether or not the community residents will take advantage of such an opportunity to participate in project planning remains to be seen, but EPA must ensure that the opportunity is provided.

4. Interceptor Design and Land Use Data

This section presents an analysis of the data collected in the study of 52 selected interceptor sewer projects. Following a brief introduction and summary of results, the detailed analysis is presented in three parts, one covering the physical design of the project, a second dealing with the economies of interceptors, and a third discussing measures of excess capacity and possible land use impacts.

The section on the physical design aspects of the interceptor project is largely descriptive and provides an overview of the size and scope of the projects in our sample. This is accomplished through the presentation of summary statistical measures for three parameters: the ultimate population served, the ultimate flow, and the length of the interceptors. In addition, we discussed three parameters related to engineering design practices, the design per capita flow, the implied per capita flow (ultimate residential flow/ultimate population) and the ratio of peak to average flow.

Nominal per capita flow was 100 gpcd in 70% of the projects studied. In the other 30%, a higher nominal figure was used; these were projects in more urbanized areas. Implied Per Capita Flow was somewhat higher than nominal per capita flow, being the actual design flow of the system divided by the design population. While 100 gpcd was the mode, other projects showed substantially higher figures, reflecting the average of the infiltration allowance on a percapita basis. Infiltration was sometimes averaged in with the 100 gpcd figure, which was itself often reflective of EPA design preference rather than based on actual flow data, and was interpreted flexibly by the engineers when measured per capita flow was low and infiltration moderate.

In the section on economics we discuss the factors influencing interceptor costs and the cost data obtained in the present study. An equation for estimating the cost per mile of interceptors as a function of ultimate flow has been developed from a regression analysis of our data and indicates that the elasticity of cost with respect to flow is about 0.51. This figure is in agreement with earlier work by other researchers. The results of this analysis are then employed in examining the relative costs of different interceptor staging strategies. We conclude that, depending upon the excess costs involved in adding additional capacity, it may be possible to employ shorter design periods in rapidly growing areas without significantly increasing costs. The results of our regression study are also employed in defining a new variable, BURDEN, which is a measure of the per capita costs of excess capacity. The mean burden per capita was $145, and it ranged as high as $658. This figure has significance to planners, who must design the financing of the local share of sewer construction.

The third major section of the analysis of 50 interceptor projects focused on the evaluation of four dimensions of excess capacity, ratio of ultimate to initial population, the percentage of the land in the service area which is vacant and developable, the implied number of years to reach ultimate capacity at present growth rates and the USR&E measures of excess capacity, "BURDEN," which is discussed in detail in the economics section. It was found that each of these four indicators was highly correlated with the others and that individually, or as a composite variable, they offered at least a first indication of projects in which large excess capacity may interact with land use.

The statistical data has important implications for land use planning. We have demonstrated that, in the typical case, the federal government is funding projects with large excess capacity in suburban areas with rapid growth. Over half the land served by a project is typically vacant. The mean cost of the excess capacity is $145 per capita distributed amongst the existing population. Seventy-five percent of that, or about $108, is being paid by EPA. Clearly then, EPA is funding the future development of vacant land on a large scale.

Of equal interest is the fact that the typical case has a high growth rate--a mean of 7%, a median of 2%. In our analysis of staging, we found that if a project involved a population growth rate of 3%, and even if future construction becomes twice as expensive in real terms as it is now, a twenty-five year design period is cheaper than a fifty year design period. Yet the median design period of the projects studies is over fifty year, the mean 105 years. We must conclude that the great amount of money being spent to subsidize the sewering of vacant land is not being spent in the most cost effective manner. If we pro rate the expense of building the interceptors equally between vacant and settled land, then more than half of the government funds are being inefficiently spent to subsidize the development of vacant land. We must bear in mind that the sample selected was not random, but was oriented toward projects with large excess system capacity. However, considering the random normal distribution of the proportion of vacant land in the sample, and the sketchy quality of the data on which the sample was originally selected, our conclusions may be generalized to a certain extent. If one ignores EPA projects in which replacement sewers were being funded, which represented a considerable portion of the remainder of the projects from which the fifty projects analyzed were extracted, then our sample becomes more highly representative of projects in which new construction is being funded, and in which land use considerations are most important.

In Appendix A we present a detailed description of the categories of data obtained in the project study. This explanation includes the source of the item, the reason it is of interest, its general availability, and where appropriate, our evaluation of the reliability of the information. This information is followed, in Appendix B, by the data tables, organized by region and state.

The tables in the Appendix to this Volume contain information on a total of 52 EPA grant projects, however, in most cases the data available for an individual project were somewhat incomplete. In addition, in preparing this section of the report we were interested only in information relating directly to the interceptors. Thus if design year rather than ultimate year information was given in the data tables for implied years to design of flow, these data were regarded as missing for the purposes of the analysis. Missing data were excluded from the calculation of the statistical parameters presented in the pages which follow. As a result each of these parameters is based upon a different sample size; for each of the statistics the relevant sample size is indicated in the figures and tables contained in this section.

In a few cases a single grant covered two or more interceptor projects which we felt to be both logically and physically distinct. In these cases the individual interceptors have been treated as separate projects. Consequently, the total number of cases considered was 54.

4.1 Physical Design

The purpose of this subsection is twofold. First, it serves as a summary presentation of the nature of the projects in our sample. This is accomplished through a description of three parameters relating to the size and impact of the project, the ultimate flow, the ultimate population and the length of interceptors in the project. This information will be of particular interest to those who are interested in determining the extent to which the projects selected for case study are representative of the entire 50 project sample. A second purpose of this subsection is to discuss various aspects of interceptor design practices. This discussion is centered on the parameters - nominal per capita flow, implied per capita flow, and the ratio of peak to average flow.

4.1.1 Ultimate Population Served

Although both ultimate population and ultimate flow measure essentially the same aspect of project size, in the present case the ultimate population statistics can be considered more representative of the entire sample, since there were only 14 missing values associated with this item as compared to 29 for the ultimate flow. The distribution and essential statistics for the ultimate population are presented in Figure 1. It can be seen that most of the projects studied are in the small to medium size range. Although the mean project size was about 114,000, over half the projects studied had ultimate populations less than 50,000 and over 30 percent of the projects will ultimately serve less than 20,000 people. The relatively large number of small projects in the sample chiefly reflects the distribution of the two southern Regions, where population concentrations are smaller than in the New York Region and where a number of small communities such as Jeffersonville, Ga., and Walterboro, S.C., received complete collection systems. Another factor influencing the distribution is that in some cases the individual grants represented only part of a much larger system.

4.1.2 Ultimate Capacity

Although based upon a much smaller sample, the ultimate flow statistics follow essentially the same pattern as the ultimate population, as shown in Figure 2. Once again the mean of approximately 11.2 MGD is slightly more than twice the median flow and the comments made with regard to the ultimate population apply here as well.

FIGURE 1
DISTRIBUTION OF ULTIMATE POPULATION

```
     C. THRU 8500C          I
                            ************************************************* (     25)
                            I
                            I
                            I
  8500C. THRU 170000.       ************* (     6)
                            I
                            I
                            I
 170000. THRU 255OCC.       ***** (     2)
                            I
                            I
                            I
 255C00. THRU 340CCC.       ***** (     2)
                            I
                            I
                            I
 340000. THRU 425000        ******* (     3)
                            I
                            I
                            I
 4250C0. THRU 510000.       *** (     1)
                            I
                            I
                            I
 510000. THRU 5550C0.       *** (     1)
                            I
                            I
                            I

VARIABLE  ULTPOP     ULTIMATE POPULATION

MEAN        114264.375          STD ERROR   24223.727          STD DEV     153204.313

VARIANCE    **********          KURTOSIS        1.635          SKEWNESS         1.622

RANGE       588000.000          MINIMUM      2000.000          MAXIMUM     590000.000

VALID   OBSERVATIONS -      40
MISSING OBSERVATIONS -      14
```

FIGURE 2

DISTRIBUTION OF ULTIMATE FLOW (MGD)

```
              I
0. THRU 5.    ******************************** (      13)
              I
              I
              I
5. THRU 10.   ********** (      4)
              I
              I
              I
10. THRU 15.  *** (      1)
              I
              I
              I
15. THRU 20.  *** (      1)
              I
              I
              I
20. THRU      *************** (      6)
    HIGHEST   I
              I

VARIABLE  FLOW       ULTIMATE FLOW IN MGD

MEAN          11.178          STD ERROR     2.858          STD DEV       14.291

VARIANCE     204.231          KURTOSIS      0.005          SKEWNESS       1.222

RANGE         45.080          MINIMUM       0.220          MAXIMUM       45.300

VALID   OBSERVATIONS -     25
MISSING OBSERVATIONS -     29
```

4.1.3 Length

Figure 3 displays the statistics relating to the lengths of the projects. The length ranged from a minimum of .4 miles to a maximum of 86.8, the latter being a complete collection system in Washington County, Tennessee. As in the case of the ultimate population and flow the distribution is somewhat skewed, with the median occurring at 5.1 miles. The simple correlation between length and the other two measures of project size, ultimate population and ultimate flow, is positive and significant at the 1 percent level, as the table below indicates. Thus the larger the ultimate population, the longer the interceptor. This relationship is, of course, not surprising, however the disproportionate length of sewers in those small projects where complete collection systems were installed was expected to weaken the statistical significance.

	Length With Ultimate Pop.	Length With Ultimate Flow
Simple Correlation	.5378	.6594
Significance (2 tailed)	.001	.001

4.1.4 Per Capita Flow

The nominal per capita flow employed by project engineers was 100 gpcd in 70% of the projects for which

FIGURE 3
DISTRIBUTION OF LENGTH (MILES)

```
 0. THRU 5.      I*******************************************************  (    25)
                 I
                 I
 5. THRU 10.     I************************  (    11)
                 I
                 I
10. THRL 15.     I*******  (     3)
                 I
                 I
15. THRL 20.     I*********  (     4)
                 I
                 I
20. THRU 25.     I*********  (     4)
                 I
                 I
25. THRL         I***********  (     5)
    HIGHEST      I
                 I

VARIABLE  LNGT       LENGTH IN MILES

MEAN            11.703          STD ERROR        2.450          STD DEV        17.666
VARIANCE       312.103          KURTOSIS         9.469          SKEWNESS        2.993
RANGE           86.400          MINIMUM          0.400          MAXIMUM        86.800

VALID   OBSERVATIONS -       52
MISSING OBSERVATIONS -        2
```

this item was available. In the remaining projects the per capita flow was somewhat above this figure, these projects generally tending to be in the more heavily urbanized areas. There was no significant regional difference in this respect.

The use of 100 gpcd as a design figure appears to be based upon EPA policy rather than any general consensus in the engineering profession. In fact a number of engineers in southern states felt strongly that this figure was unreasonably high, particularly for rural areas. To the extent that these engineers are correct, EPA policy is, in effect, forcing additional reserve capacity to be built into the interceptor systems. As discussed below, however, this effect is somewhat counterbalanced by the interpretation placed upon the 100 gpcd figure by the consulting engineers.

4.1.5 Implied Per Capita Flow (Ultimate Flow/Ultimate Population)

This measure reflects considerably more variation than the nominal per capita flow as Figure 4 indicates. While the mode is still 100 gpcd the mean is 122 gpcd, somewhat higher than the mean of 111 for the nominal figure. This difference is reasonable given the fact that the implied per capita flow includes the assumed

FIGURE 4

DISTRIBUTION OF IMPLIED PER CAPITA FLOW (GPCD)

```
                  I
LOWEST THRU 70.   *****(       2)
                  I
                  I
                  I
7C. THRL 85.      ***(       1)
                  I
                  I
                  I
85. THRL 10C.     ********************************************************** (      23)
                  I
                  I
                  I
100. THRU 115.    *************** (      6)
                  I
                  I
                  I
115. THFU 130.    ********** (      4)
                  I
                  I
                  I
120. THRU         ************************* (      10)
     HIGHEST      I
                  I


VARIABLE  IMPPC      IMPLIED PER CAPITA FLOW IN GPCD

MEAN          122.174              STD ERROR       10.436                 STD DEV        70.784
VARIANCE     5010.324              KURTOSIS        12.838                 SKEWNESS        3.304
RANGE         456.000              MINIMUM         11.000                 MAXIMUM       467.000

VALID   OBSERVATIONS -      46
MISSING OBSERVATIONS -       8
```

infiltration, while the per capita design flow generally should not. However in many cases the figure of 100 gpcd was interpreted as including infiltration allowance. Apparently what has happened is that in areas where engineers felt that the use of 100 gpcd was too high they partially adjusted for this by including infiltration as part of the 100. In other areas, where infiltration problems are severe, an additional allowance for this effect was added to the 100 gpcd figure.

4.1.6 Ratio of Peak to Average Flow

While design requirements are usually stated in terms of average daily flows, in fact considerable seasonal and daily variation in flows occur. Elements of a wastewater collection system must thus be designed not for average flows but for the peak flow. Failure to provide for proper peak capacity can result in the bypass of untreated sewage into receiving waters and backup of sewage into streets and homes. On the other hand employing a peak to average flow ratio in excess of currently accepted standards would effectively provide additional reserve capacity in the system. For this reason the ratio of peak to average flow employed in the design of each project was obtained, if available.

There are currently two methods employed in establishing the ratio of peak to average flow in interceptor design. The simplest is to employ a constant ratio independent of the average flow of the sewer. This factor generally ranges anywhere from 2.0 to 3.5. The second approach is to utilize a design equation or graph which relates the ratio of peak to average flow to total population served or average flow.[1] While the exact relationship varies from consultant to consultant, the ratio generally decreases from about 5.0 for small populations (<1,000) to a minimum of 1.5 for large service populations (>500,000). This latter method is intuitively more satisfactory, since it takes into account the averaging effects of large populations. In practice it tends to be somewhat more conservative than the fixed ratio approach for small service populations and less conservative for large populations.

Among the projects studied the fixed ratio method was employed extensively in the Atlanta and Dallas Regions, while variable ratio methods predominated in the New York Region. Of the projects which employed fixed ratios, the Tuskegee, Alabama interceptors had the highest ratio, 3.5, while the most common figures were 2.0 or 2.5. In no case was the ratio employed out of line with "acceptable" engineering standards. The broader question of whether current standards are, in fact, too conservative is one which, in our opinion, has never been adequately examined. It was not within the scope of this study however to undertake such an analysis.

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[1] Metcalf and Eddy, Inc., Wastewater Engineering, McGraw Hill, New York, 1972.

4.2 Economics

Despite the fact that collection and transmission costs comprise between 50 and 80 percent of the capital costs of wastewater disposal, generalized cost equations for sewers appear to be much less well developed than those for treatment plants. Such predictive tools are essential in determining the optimal tradeoff between treatment plants and interceptors in a regional treatment scheme, evaluating the overall sensitivity of costs to this tradeoff, and determining appropriate staging policies. Related to the regionalization issue is the question of whether, as some claim, extensive regionalization promotes sprawl by opening up large tracts of land for premature development through the extensive use of cross country interceptors. If this question is answered in the affirmative, then it will be of interest to examine the cost effectiveness of employing a more decentralized scheme to control growth.[2] Once again robust interceptor cost estimating techniques are essential in such an analysis. Of particular interest is the elasticity of cost with respect to size.

As a result of the importance of accurate cost relationships, we have devoted a considerable amount of effort to the analysis of the cost data gathered in the 50 project study. In this subsection we summarize the results of this aspect of our study. We begin with a general discussion of the considerations involved in the economic design of sewers, and then summarize some of the past attempts at developing general cost relationships. Following this introductory material we present a statistical description of the cost data gathered in our study and an equation relating cost to average flow which was developed by employing regression techniques to our data. This equation is then employed to explore the economic consequences of different design periods for interceptors.

In the remainder of the subsection we examine the relationship between ultimate density and per capita cost, and introduce a measure of the per capita cost of providing reserve capacity.

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[2] Dajani and Gemmell have shown that decentralized system, if properly operated, can provide superior water quality to highly centralized systems by making better use of the assimilative capacity of the receiving waters and averaging out stochastic fluctuations in the performance of the plants. "On the Centralization of Wastewater Treatment Facilities" Water Resources Bulletin 8(4), Aug. 1972 p. 669.

4.2.1 Sewer Design

The basic equation employed in the design of gravity sewers is the Manning Equation,[3] which relates the flow or velocity in the pipe to the pipe diameter, the slope and a roughness factor characteristic of the pipe material. In order to achieve a particular design flow the designer is free to adjust the slope and pipe size subject to certain limitations upon the minimum and maximum velocities, and the relationship of the Manning Equation. These two parameters in turn translate into the two major cost components, pipe costs and excavation and fill costs. Thus the central economic problem is to select the combination of diameter and slope which provides the optimal balance between material and construction costs. For a single pipe in a flat plain with common earth this is a relatively simple problem. In real collection systems, however, a number of complicating factors arise. Routing becomes of critical importance; topography may aid the designer by allowing him to follow natural drainage patterns and thereby minimize excavation costs, or it may hinder him if the terrain is hilly or irregular. Excavation costs vary considerably depending upon such factors as soil composition, depth to bedrock, depth to water table, and the extent of previous development. In a network the design of individual sections is no longer independent, as each pipe influences the optimal design of the succeeding section, thus independent optimal design of each pipe in the system will lead to an overall suboptimal solution. Finally lift stations may be employed, thereby substituting operating costs for the capital costs of excavation or force mains may be employed in place of gravity sewers. Because of these complexities, sewer design remains very much an art, although some recent progress has been made in the development of computer routines capable of handling these problems.[4]

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[3] Metcalf and Eddy.

It is important to keep the above considerations in mind because in the analysis which follows we avoid these elements of detailed design and attempt to explain the construction cost of interceptors on the basis of average flow alone. Two crucial assumptions are implicit in this approach; that the designers of the projects in our study come up with very good, if not optimal, solutions to the design problems posed above, and the site specific characteristics of these projects are representative of the country as a whole. Even if these assumptions are fulfilled, however, we would expect a considerable amount of unexplained variance in our analysis as a result of site specific differences in topography, soil, and geology, and differences in standard design methods such as the ratio of peak to average flow employed.

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[4] Dajani and Gemmell.

4.2.2 Cost Equations

Costs for environmental structures such as water and wastewater treatment plants and transmission lines have traditionally been expressed in the simplified form:

$$\text{Cost} = a(\text{capacity})^{b}$$

where a is a constant and the coefficient b is the elasticity of cost with respect to capacity. If b is less than 1 the facility is said to have economies of scale. Economies of scale are characteristic of most environmental facilities and provide the economic rationale for regionalized systems and long design periods. Sewers are thought to have among the most significant scale economies (smallest b) of these facilities because of the high component of fixed costs associated with excavation. Spencer[5] suggested the following formula, based on an Engineering News Record Construction Cost Index of approximately 1000:

$$\text{Cost/Mile} = 46{,}000\ (\text{MGD})^{.55}$$

or

$$\$1000/\text{MGD/Mile} = 46\ (\text{MGD})^{-.45}$$

In 1966 Bauer[6] proposed a similar equation based upon data from the Chicago area:

$$\$1000/\text{MGD/Mile} = 40\ (\text{MGD})^{-.50}$$

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[5] Spencer, C.C. "Metropolitan Planning for Sewers on a County Basis", Public Works 89(8), Aug. 1958 p. 83

[6] Bauer, W.J. "Economics of Urban Drainage Designs" Proc ASCE, 88 (HY6) Nov. 1966, p. 93

More recently Smith and Eilers[7] have computed estimated interceptor costs for a variety of conditions. For a slope of .001 their results, when adjusted to January 1973 by the ENR Construction Cost Index, can be expressed as

$$\$1000/\mathrm{MGD}/\mathrm{Mile} = 132(\mathrm{MGD})^{-.50}$$

where 3.5 has been chosen as the ratio of peak to average flow. Thus the scale factor, b, reported in the three papers is about .50. As a point of comparison the corresponding factor for sewage treatment plants is thought to be 0.7 to 0.8[8].

The use of a simplified power relationship of the type described above is extremely attractive, and in fact we have employed this functional form in the analysis of the 50 project data. However it is recognized that this is a severe simplification which can be misleading if used for the purposes of extrapolation. For example the economies of scale in sewage treatment plants begin to disappear for very large projects [9] and we suspect that the same holds true for interceptors as well. Thus extrapolation of the simple power relationships would lead to overregionalization and overcapacity.

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[7] Smith, Robert G. and Richard G. Eilers Economics of Consolidating Sewage Treatment Plants by Means of Interceptor Sewers and Force Mains FPA, April 1971

[8] Ibid

[9] Ibid

4.2.3 Cost Data

Figure 5 summarizes the cost data gathered in the 50 project studies. Individual costs ranged over almost three orders of magnitude, from $44,000 for Greenbriar, Arkansas to $42,000,000 for the Staten Island system. These costs reflect only construction costs for interceptors and appurtenances; legal and engineering fees and land acquisition and contingency costs have been excluded if possible. In general these factors would add another 25% to the interceptor costs. The distribution of costs reflects the skewed nature of project sizes which was commented upon earlier. While almost half of the projects are less than $1,000,000, these projects account for only a small fraction of the total resources allocated. The New York Region, where funds were allocated almost exclusively for large projects, had an average project cost significantly greater than the two southern regions. None of the projects in the New York region were less than $1,000,000.

4.2.4 Regression Analysis

We have attempted to apply regression analysis to our data in order to derive an equation for estimating interceptor construction costs. The dependent variable, cost, has been expressed in terms of $1000/MGD/Mile, and the independent variable chosen was ultimate average flow, in MGD. Because of missing data, the actual sample available for this analysis

FIGURE 5

DISTRIBUTION OF COST (DOLLARS)

```
0. THRU 5000000.            ***********************************************************************************  (   40)
                            I
                            I
                            I
5000000. THRU 10000000.     *******  (    3)
                            I
                            I
10000000. THRU 15000000.    ***  (    1)
                            I
                            I
                            I
15000000. THRU 20000000.    *****  (    2)
                            I
                            I
                            I
20000000. THRU 25000000.    **  (    1)
                            I
                            I
                            I
25000000. THRU 30000000.    ***  (    1)
                            I
                            I
                            I
30000000. THRU 35000000.    **  (    1)
                            I
                            I
                            I
35000000. THRU  HIGHEST     *****  (    2)
                            I


SEWERS

FILE    SEWERS    (CREATION DATE = 07/27/74)


VARIABLE  COST      COST IN 1000 DOLLARS

MEAN         5530.875          STD ERROR      1447.170          STD DEV      10334.859
VARIANCE     **********        KURTOSIS          4.994          SKEWNESS         2.429
RANGE       41955.992          MINIMUM          44.007          MAXIMUM      42000.000

VALID   OBSERVATIONS -        51
MISSING OBSERVATIONS -         3
```

was only 22 cases. As a result it was necessary to pool the data from the three regions in running the analysis. We have a number of reservations about employing our cross-sectional data in this manner to produce an estimating equation. Two of these relate to problems which have been discussed previously; the fact that our cost data comes from a variety of sources and reflects a range of years rather than a single point in time, and the problem of site specific variations in design conditions and methodologies. Neither of these factors could be controlled in our analysis. In addition, our data includes a variety of project types and configurations, from single collectors to complete collection systems. Yet despite these variance contributing factors, a preliminary graphical analysis indicated that the overall consistency of our data was sufficient to warrant further analysis.

We attempted to fit a number of functional forms to the data, including linear, semi-log, and log-log relationships. The most successful of these was the log-log form:

$$\log (\$1000/\mathrm{MGD}/\mathrm{mile}) = b_o + b_1(\log (\mathrm{MGD}))$$

which is just a logarithmic transformation of the standard power form relationships discussed previously. Only the regression results for this functional form will be discussed here, and these are presented below:

Coefficient	Value	Standard Error	T-Ratio
b_o	4.838	.193	25.131
b_1	-.49228	.08522	-5.777
F(1,20) =	33.371		
Corrected R^2 =	.6065		

Thus the results of the regression are significant at the 1% level and slightly over 60% of the variance (in logarithmic form) has been explained. In terms of the untransformed equation:

$$\$1000/MGD/mile = 126\ (MGD)^{-.49}$$

The elasticity of total cost with respect to flow implied by this relationship is 0.51. In Figure 6 the regression line is plotted with the original data and in Figure 7 it is plotted along with the equations of Spencer,[10] Bauer[11] and Smith and Eilers.[12] It can be seen that our estimate of the scale factor agrees closely with the previous work; however, it should be pointed out that there is a considerable degree of uncertainty associated with our estimate, as the 95% confidence interval ranges from -.32 to -.66.

Having established a reasonable basis for the estimation of interceptor costs, we then proceeded to apply these results to analyze the issue of interceptor design periods.

4.2.5 Interceptor Staging

It has been traditional engineering practice to design interceptor and other sewers to meet the anticipated

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[10] Spencer, C.C., Op. Cit.

[11] Bauer, W.J., Op. Cit.

[12] Smith, Robert G. and Richard G. Eilers, Op. Cit.

FIGURE 6. COST VS. CAPACITY OF INTERCEPTOR PROJECTS

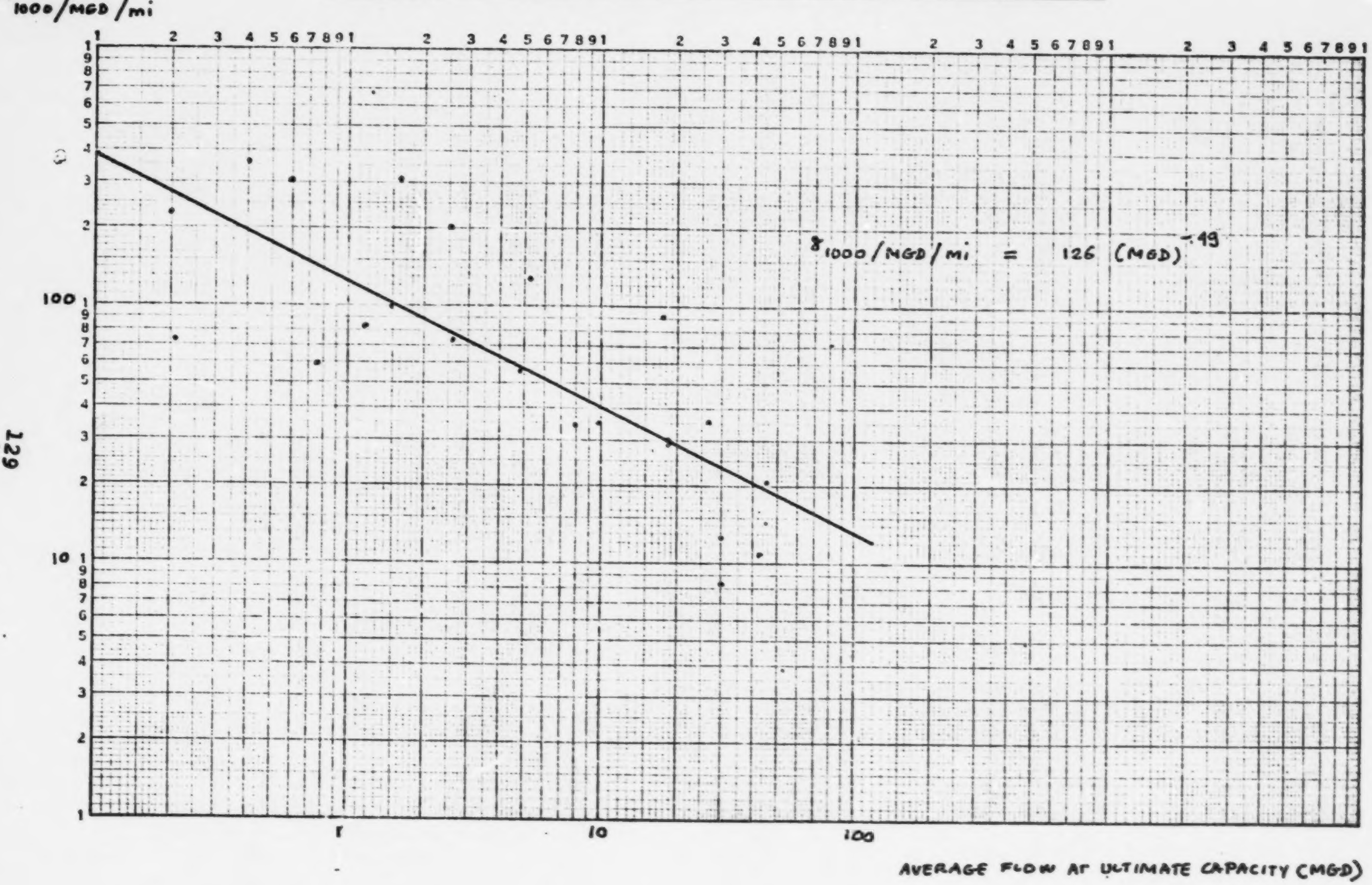
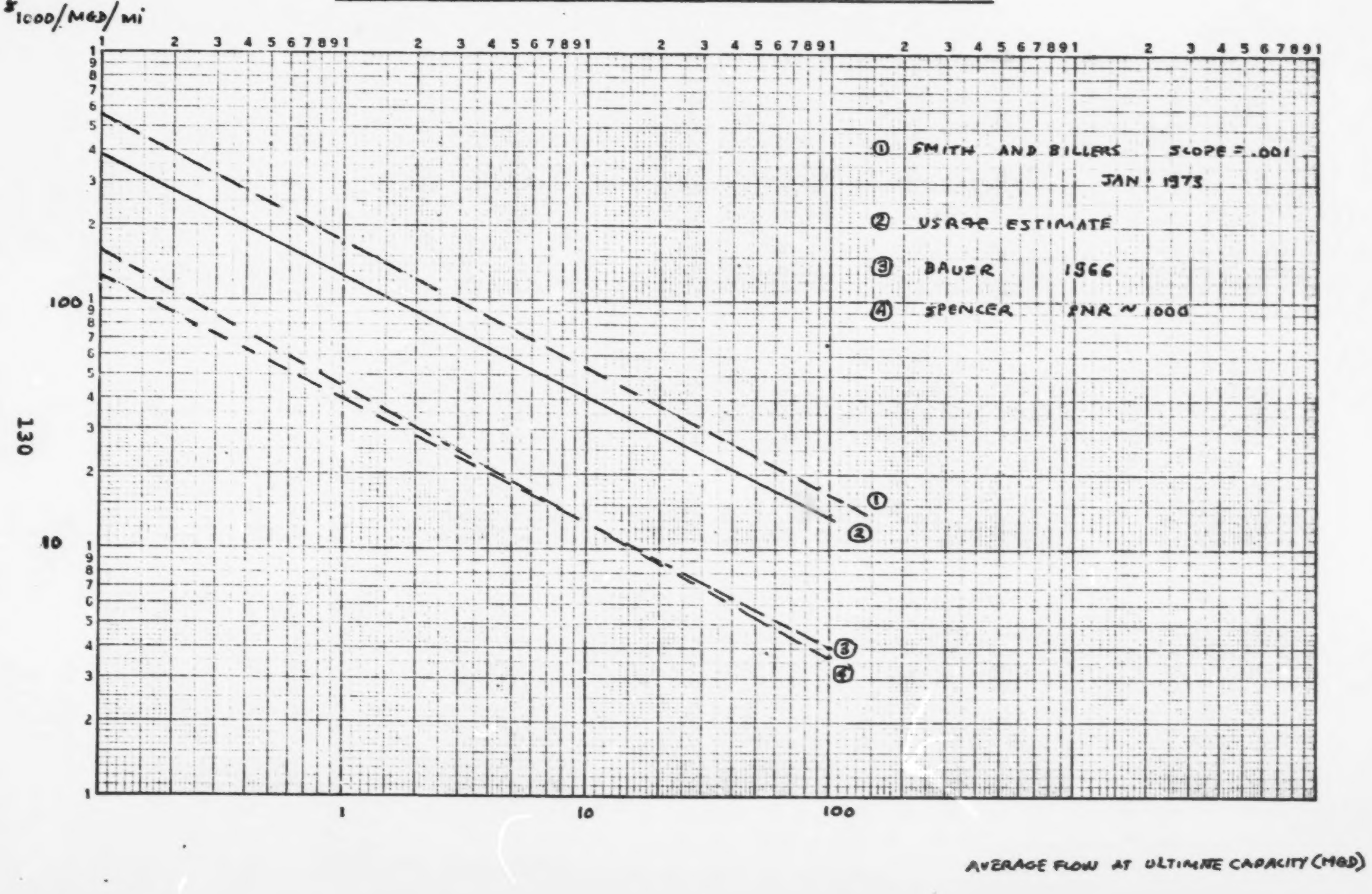


FIGURE 7. COMPARISON OF COST CURVES



requirements for 50-year periods, and sewage treatment plants for about half that time. In the majority of projects investigated in this study this philosophy has been maintained. The rationale for long design periods for sewers has been based upon three factors: the invariant technology of wastewater collection which makes technological obsolescence unlikely, the fact that the real costs of replacing or adding sewers increases as an area becomes more developed, and the large economies of scale associated with installing and maintaining sewers. As one project engineer put it, "It costs nothing to use a bigger pipe."

Although these arguments are persuasive, the fact remains that in most of the engineering reports which we studied there was no serious attempt made to consider the relative merits of alternative staging policies. In addition some have argued that employing shorter design periods might be worthwhile in some instances as a land use control, even if it means slightly higher project costs. Because of these considerations, we have undertaken a study of interceptor staging policies. This study investigates the influence of two of the factors mentioned above, scale economies and the penalty costs of replacement, upon the economic choice of design periods.

A considerable amount of effort has been devoted in recent years to the study of optimal dynamic staging policies in a variety of public and private sector problems. It was not our intent to repeat this work here. Rather, we have focused upon a much simpler issue, the comparison of 25-year and 50-year design policies for interceptors. We feel that this choice is reflective of current design methodology. We have postulated the following simple model:

1) A service area with initial population P_o will grow linearly over a 50-year period, at the end of which it will be at its maximum population.
2) r = the annual growth as a fraction of the year 0 population.
3) i = interest rate
4) Z = the factor by which the real cost of sewerage increases if it is installed after year zero.
5) The cost is assumed to be expressed as $c = a(P)^b$ where a is a constant, b is the scale factor as before, and P is the design year population.
6) We shall compare the present value of the two strategies, 25-year and 50-year design periods. We deal with real costs only; inflation is not included.

The cost for a 50-year design period becomes:

$$PV_{50} = a(P_o + rP_o(50))^b$$

$$= aP_o^b\ (1 + 50r)^b$$

and for 25-year design periods:

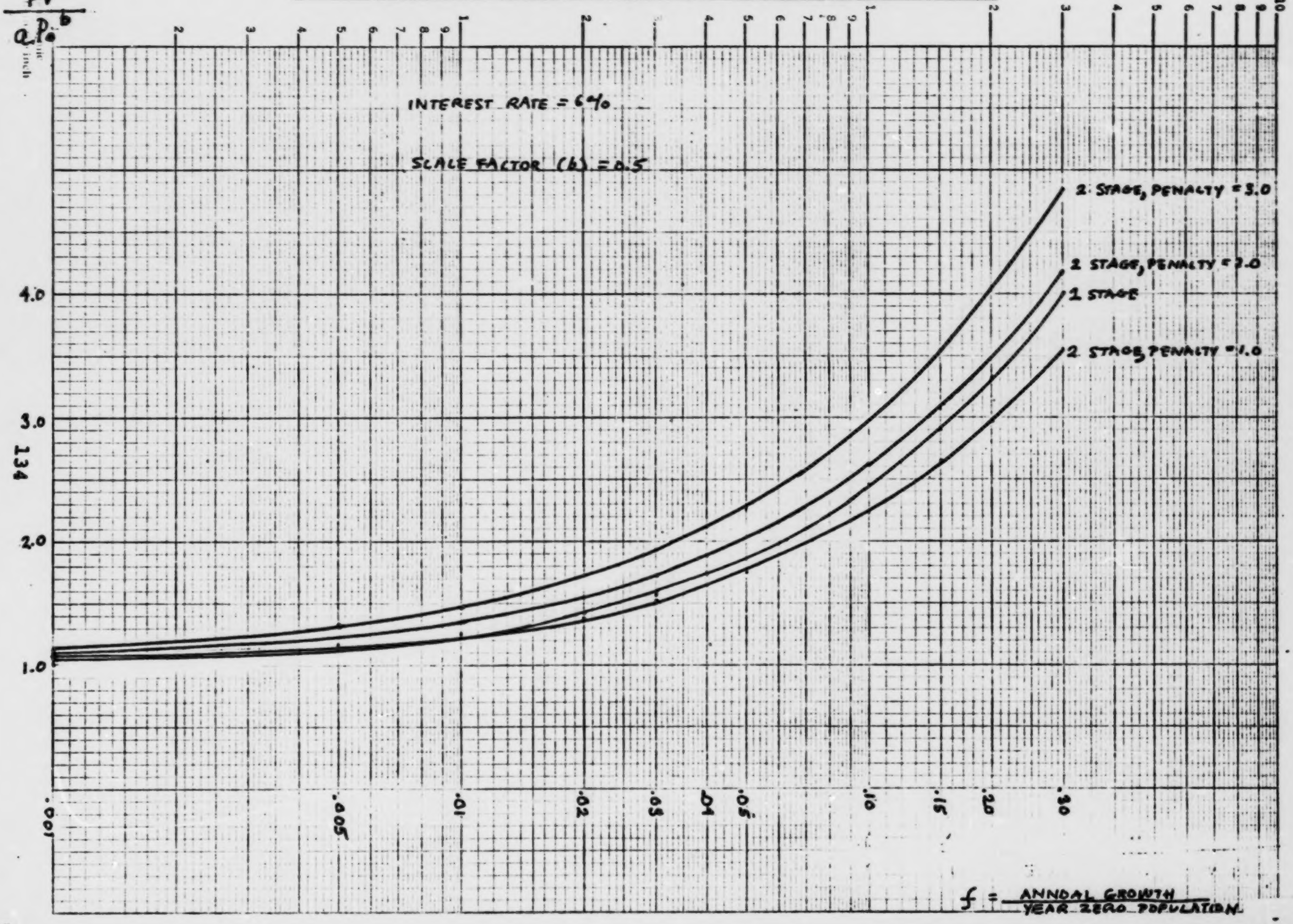
$$PV_{25} = aP_o^b\ (1 + 25r)^b + \frac{Z \cdot aP_o^b}{(1 + r)^{25}}\ (r25)^b$$

The two present values can be expressed as dimensionless costs by dividing each equation by the constant factor aP_o^b without affecting the comparison between costs. This has been done and the equations coded for computer evaluation of a number of design situations. The conditions investigated included scale factors from .4 to .7, penalty factors from 1 to 3, interest rates from 4 to 8%, and growth rates from .001 to .35. A case representative of current design situations is shown in Figure 8. A 6% interest rate is employed and the scale factor assumed is 0.5, in agreement with the findings of our regression analysis. The vertical axis presents the dimensionless cost $\frac{PV}{aP_o^b}$ while the horizontal axis indicates the growth rate r.

For growth rates above 1% of the year zero population and no penalty, the 25-year strategy is actually superior to the longer design period. As the penalty factor increases, however, the 50-year policy begins to dominate. Thus at a penalty of 2.0, a 50-year period is superior over all growth rates, but it should be noted that the maximum difference is only 10% of the 50-year costs, thus at this penalty factor, a strategy of staging to control land use would not be financially unrealistic.

The results for other design cases, while not presented here, follow logically in that at higher interest rates or smaller economies of scale the 25-year strategy gains comparative advantage. For example, at 8% interest with the same

FIGURE 8. COST VS. FRACTION ANNUAL GROWTH



scale factor, the 25-year design period is superior over all growth rates at $z = 1.0$ and over all growth rates greater than .03 at $z = 2.0$.

Our conclusion from this analysis is that the choice between 25 and 50-year design periods is not necessarily as clear cut as some engineers might believe. It is influenced strongly not only by scale factors and interest rates, but by the magnitude of the penalty factor as well. Moreover, over certain ranges of the parameters, the cost response surface is flat enough so that other factors besides least cost considerations can influence the decision without a dramatic loss of economic efficiency.

4.2.6 Per Capita Cost and Density

Synthetic costing studies by Dajani and Gemnell[13] and the Real Estate Research Institute[14] have shown that there is a strong relationship between residential density and per capita wastewater collection cost. In the latter study, it was found that for a hypothetical community of 10,000 units, total pipeline costs for sanitary sewerage amounted to $9,412,957 under a "low density sprawl" type of development (predominantly single-family homes) as compared with $4,532,515 for the same number of dwelling units in their more compact "planned mix" category (a mixture of conventional homes, clustered homes and townhouses, walk-up apartments and high-rise apartments).

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[13] Dajani and Gemmel, Op. Cit.

[14] Real Estate Research Corporation, Environmental and Economic Affects of Alternate Development Patterns, Task II, Detailed Cost Analysis, August 1973.

The cost savings associated with more compact development stems primarily from two factors, the decreased length of pipe required per dwelling unit, and the fuller utilization of laterals, which, because of engineering standards on minimum allowable size operate below full capacity in low-density residential areas.

Although the studies cited above were concerned primarily with laterals and second-order collectors, it is logical that the larger trunk and interceptor sewer costs would be affected by density in a similar manner. Thus per capita costs for interceptors should decrease with increasing density. This hypothesis was investigated by computing the simple correlation between these two variables, with the per capita cost defined as the total project cost divided by the ultimate population and the density defined as the ultimate density. Both linear and logarithmic relationships listed in the 50-project data have been investigated.

Since many of the projects studied consisted of only one phase of a much larger system of interceptors and trunk sewers, it was not clear whether even if the proposed relationship did hold, it would necessarily be reflected by our data. Nevertheless, the simple correlations investigated were in the predicted direction, although the relationships were not significant at the 5% level, based upon a two-tailed test. These correlations are tabulated below and are based upon a sample size of 34.

	Density	log (density)
Per capita cost	-.1484 (s=.402)	-.3193 (s=.066)
log (per capita cost)	-.2759 (s=.114)	-.0803 (s=.652)

The top number in each box is the simple correlation and the figure in parenthesis is the significance level for a two-tailed test. The correlation between per capita cost and the natural log of density was the most significant, at 6.6%, and indicates that the log of density explains approximately 10% of the total variance in the per capita costs.[15] Thus the results of this analysis have supported, although weakly, the contention that per capita costs of major collectors are incersely related to projected service area densities.

4.2.7 BURDEN

The results of our investigation of the relationship between interceptor cost and flow have been employed in the definition of an economic measure of excess capacity. This measure, which we term BURDEN, reflects the per capita costs associated with providing reserve capacity, based upon the current population of the service area. In addition to providing a measure of excess capacity, BURDEN also reflects upon equity considerations. Our case study analysis has shown that in some projects, for example Fulton County, Georgia and St. Bernard, Louisiana, current residents bear most of the local share of the interceptor costs. Under these circumstances, BURDEN measures the extent to which current residents will be, in effect, subsidizing future sprawl.

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[15] The square of the simple correlation is the coefficient of determination, or uncorrected R^2, which would be obtained in a regression between the two variables.

Consider two interceptors, one designed to handle only the current population of a service area, P_o, the second designed to handle the ultimate population P_u. The capital costs of these projects would be $a(qP_o)^{.50}$ for the former and $a(qP_u)^{.50}$ for the latter, where q is the per capita flow and the .50 is, as before, the scale factor selected on the basis of our regression and work referenced previously. Assuming that the ultimate project is, in fact, built at cost C_u the cost of the smaller project would then be estimated as $\left(\frac{P_o}{P_u}\right)^{.5}\text{Cost}_u$ and the cost difference between ultimate and initial population projects would become:

$$\left(1 - \left(\frac{P_o}{P_u}\right)^{.5}\right) X \text{ Cost}_u$$

Dividing this term through by the present population, we obtain one measure of per capita excess cost:

$$\text{BURDEN} = \frac{\left(1 - \left(\frac{P_o}{P_u}\right)^{.5}\right) \quad \text{Cost}_u}{P_o}$$

The distribution of this parameter is presented in Figure 9. The median and the mode of these were both about 100, however there were several very high projects which raised the mean up to 145. The relationship between BURDEN and several measures of excess capacity are discussed below.

FIGURE 9
DISTRIBUTION OF BURDEN

(PER CAPITA COST OF EXCESS CAPACITY)

```
0. THRU 40.      ****************************************  (     7)
                 I
                 I
40. THRU 80.     **********************************************  (     8)
                 I
                 I
80. THRU 120.    ***************************************************************  (    11)
                 I
                 I
120. THRU 160.   ******  (     1)
                 I
                 I
160. THRU 200.   ***********  (     2)
                 I
                 I
200. THRU 240.   ***********  (     2)
                 I
                 I
240. THRU        **********************************  (     6)
      HIGHEST    I
                 I

VARIABLE  BURDEN     PER CAPITA COST OF EXCESS CAPACITY

MEAN           145.473          STD ERROR         26.100          STD DEV        158.759
VARIANCE     25204.410          KURTOSIS           2.045          SKEWNESS         1.706
RANGE          653.940          MINIMUM            4.430          MAXIMUM        658.370

VALID   OBSERVATIONS -       37
MISSING OBSERVATIONS -       17
```

4.3 Excess Capacity

In the initial formulation of the research undertaken, probably the overriding area of interest was that of the capacity of the interceptor as related to current and future demand. We have attempted to approach this question of excess capacity, using four separate indicators: implied year in which full capacity is reached, the ratio of the initial to the ultimate population served, the service area of the intercepter, and the percent of the area to be served by the interceptor which is presently unsewered and developable. In addition to a discussion of each of these indicators individually, an attempt has been made to correlate them with each other and with a series of variables related to other economic and physical attributes of the proposed interceptors.

The first indicator of excess capacity which we used was the number of years required to reach ultimate capacity, assuming the growth rate to be the same as that from 1960 to 1970 for the geographic service area. A careful reading of the data tables in the Appendix, which reports the findings of our analysis of 52 interceptor projects in EPA regions 2,4, and 6 demonstrates the complexity of creating a comparable data base for this variable. Despite these difficulties, we feel this to be a reliable indicator of excess capacity. Out of our total sample of fifty-four interceptors, consistent data for implied years to ultimate capacity were generated for thirty-four cases. The figure for mean years to capacity was 177, with a standard deviation of 358. The distribution was heavily skewed because of two interceptor projects in the sample, Jeffersonville, Georgia, and Austin, Texas, with implied years to ultimate capacity of 610 and 2,034 respectively. When these are removed from the sample, the mean drops to 105.5, and the standard deviation to 116.8. The median number of years to capacity is 51.25 years, however, indicating the midpoint of the distribution is not dramatically different from the engineers' rule of thumb which is to design interceptors for a fifty-year life.

Our second indicator of excess capacity was a relatively simple one, ultimate population in the service area divided by the initial service area population. This indicator may be a surrogate for the economic load that must be carried by present occupants. A better and highly correlated indicator is "Burden", which was discussed earlier. The mean of this variable with thirty-eight observations, was 7.1 with a standard deviation of 7.2. This is compared with a median of 3.8. Once again the distribution was skewed to the right. This variable indicates, however, that in 50% of our cases the ultimate population of the service area was expected to be less than roughly four times the initial population, and in 50%

of the cases it was expected to be more than four times as great. Assuming the median figure of the ratio of ultimate to initial population of four and a planned period to achieve this level of fifty years, the annual growth rate would be 2%, using the mean ultimate to initial population ratio of 7.1, which implies an annual growth rate of 7.0% per year. While these are both rapid growth rates, these levels have been reached in many suburban zones.

The third indicator of the size of interceptor projects was that of the service area covered. Here again, the range in the variable was large--from a 400-acre project in the southern interceptor at Goodlettsville, Tennessee, to 107,399 acres in Nashville, Tennessee. The mean acreage for the projects studied was 21,199. The median was nearly 8,000, again indicating a heavily skewed distribution in which there were a number of very large interceptor projects relative to the majority.

The final measure of size utilized in this study was the proportion of the land within a given interceptor service area which is developable and vacant, i.e., the proportion of the land anticipating new construction on the completion of the interceptor project. As was the case with a number of variables handled within our analysis, a number of assumptions and "guesstimates" were made for those interceptor projects in which only limited data were available on potential land use.

Even with this restriction, however, it is significant to note the apparent "normal" distribution of our results. The range of our responses was from 10 to 96% with a mean of 61% and standard deviation of 19, a median of 61.5% and a mode of 60%. While one could argue that the nature of our process of estimation of missing values could have created this distribution, it is highly unlikely. In 68.3% of our observations, between 42% and 80% of the land area to be serviced is presently vacant and developable. From this, one might conclude that a large amount of federal funding is going into areas which are not developed at the present time but which may be awaiting sewer connections for that development.

From each of the variables analyzed it was possible to see that most interceptor projects are designed with a relatively high level of excess capacity. However, from the "years to capacity" variable, one can see that while the distribution is skewed quite dramatically, the median is nearly identical to the engineering rule of thumb of fifty-year life on interceptors. Probably the two most interesting variables are the relationship of ultimate to initial population and the percent of the service area vacant and developable. In both of these instances, it is obvious that interceptors are following into areas in which rapid growth is anticipated and areas in which more than 60% of the land is still available for development.

A series of hypotheses were tested concerning the relationship between the implied per capita flows of the interceptors and those measures of excess capacity discussed above. This analysis was undertaken to test relationships between the capacity of the interceptor system and the physical size and level of development of the area in which the interceptor is located. Significant relationships between flows and the measures of excess capacity were found only with the ratio of ultimate to initial population. This relationship is positive, i.e., the higher the ratio of the ultimate to initial population, the larger is the implied per capita flow (coefficient = .3076, significance 0.077). This would tend to indicate that planners projecting large population growth also project a higher level per capita flow. One possible explanation is that in projects with a relatively large increase in population, flows are estimated high as a hedge against an underestimate in ultimate population.

Table 1 shows the simple correlation matrix between the four indicators of excess capacity and the variable Burden. As can be seen from the matrix, four of the variables are significantly and positively related; implied years to design, percent of land vacant, ratio of ultimate to initial population and Burden. Not related significantly to any of the other measures of excess capacity or Burden is the size of the service area.

TABLE 1 CORRELATION MATRIX OF EXCESS CAPACITY VARIABLES WITH BURDEN

		IMPLIED YEARS		AREA		PERCENT		RAT. of POP.		BURDEN	
		Linear	Log	Linear	Log	Linear	Log	Linear	Log	Linear	Log
IMPLIED YEARS	Linear	-	-	-	-	-	X -	-	-	-	-
	Log						X				
AREA	Linear	.0095 .96	.1729 .352	-	-	-	X	-	-	-	-
	Log	.0123 .948	.0677 .718				X				
PERCENT	Linear	.3469 *.065		-.1941 .218	-.2005 .203	-	X -	-	-	-	-
	Log	X	X	X	X	X	X	X	X	X	X
RATIO OF POPULATION	Linear	.9597 .601	.7095 .001	-.0747 .665	-.1178 .494	.3244 .066	X	-	-	-	-
	Log	.7588 *.001	.8516 .001	.0435 .801	-.2446 .15	*.1979 .254	X				
BURDEN	Linear	.5541 *.001	.6166 .001	.0544 .760	-.1790 .311	.5394 *.001	X	.5553 *.001	.6781 .001	-	-
	Log	.4258 .017	.5242 .002	.460 .796	-.2357 .180	.2277 .202	X	.4756 .003	.6953 .001		

Explanation of figures in matrix

Each Pair = Coefficient
Significance level

*Significance better than 10% level

While it was not possible statistically to analyze the type of development anticipated, virtually all reports indicated that future development would involve extensive rather than intensive land use.

A series of statistical relationships were hypothesized in our preliminary work. These included the positive relationship between the size of the service area and the percent of vacant and developable land, the relationship between per capita cost and density discussed earlier, and the relationship between per capita flows and those measures of excess capacity discussed in the previous section. In addition, this section will look at the correlations between the measures of bigness discussed above.

Because all of the variables in the analysis with the exception of percent of service area vacant were highly and positively skewed, the simple correlation tests between variables were run both for the linear and the logarithmic forms of the variable. In most instances it was the logarithmic form which proved to be the most significant.

Our first hypothesis that there is a relationship between the size of the service area and the percent of vacant and developable land was not born out by our statistical analysis of the fifty interceptor projects. No statistically significant relationship was found.

The absolute size of the service area is not correlated with the other four variables listed in Table 1. Most simply stated, this may be seen as a commentary on the theme of "Big is Bad". Systems which serve large geographic areas are not necessarily systems which have a large amount of inevitable growth and development, nor are these large systems built into barren lands. While this may be the case in some areas, major works such as the Oakwood Beach facility on Staten Island or the larger New Jersey projects demonstrate that geographically large projects may be responding to major current population needs.

The three remaining variables of over capacity are highly positively positively correlated, at greater than the 5% significance level in all instances. Each of the three variables attempts to approach a different dimension of excess capacity. Implied years to design capacity incorporates present rate of population increase with ultimate capacity as an indicator of physical excess capacity. The ratio of ultimate to initial population offers a measure of anticipated growth in population, excess demographic capacity. The percentage of vacant and developable land in the service area seeks to measure geographic excess. It is significant to see that the physical, the demographic and the geographic measures are so highly correlated, indicating that any one or all three of these variables may act as an indicator of proposed systems in which there is designed excess capacity.

Table 1 contains the correlation matrix for one additional variable, the USR&E-developed "Burden". It should not be surprising that Burden correlates highly with the demographic indicator of excess capacity. The ratio of the population appears in both. The correlation between Burden and the two remaining measures, physical and geographic excess capacity, are less intuitive. The fact that Burden is highly correlated only with these variables is of further significance is that it demonstrates that this measure offers a fourth, highly correlated, measure of excess capacity. As defined earlier in this report, Burden is an attempt to measure excess capacity per capita (present population) and to give, therefore, a measure of equity. We are left then with a fourth axis of excess capacity--equity--to combine with the physical, demographic and geographic. Thus one may argue that the greater the physical, demographic or geographic level of excess capacity, the greater will be the Burden (and the lower the equity) of the current inhabitant.

1. EXPLANATION OF DATA CATEGORIES

I Project Number

II Project Name

III Initial Population in Service Area - This number represents the estimated population to be served by the system or interceptor immediately upon completion. For the most part the estimates were taken from engineers' reports or state project files. Since there is often a delay between the anticipated and actual completion dates of the project these figures may somewhat understate the true initial population. The dates associated with the listed initial population varied depending how recent the engineering reports available to use were and how optimistic the engineers were about project timing. The figures may therefore correspond to dates as early as 1970 or as late as 1978 in a few cases. This number and the two population projections described below are employed in calculating a several of measures of excess capacity and project impact which are described below.

IV Design Population of Service Area - This is the population upon which design of the treatment plants and/or pumping stations were based. These elements generally have much smaller design lives than interceptors and therefore represent the capacity limiting factors for the entire system. Where only interceptors are involved the design population will generally be the same as the ultimate population to be described below. The most common year associated with the design population was 1990. The design population is taken from population projections in the engineers' reports or state files unless otherwise noted.

V Ultimate Population of Service Area - This is the "full" population of the service area, and it usually the population upon which interceptor design is based. The most common year associated with this population was 2020. As with the other population figures, this number was obtained from engineers' reports or state files. If the reports did not give an ultimate population but did include ultimate density and service area, the ultimate population was taken as the product of these figures. The methodology upon which this figure was based varied widely from project to project. In the simplest cases it appears that the engineers would make some estimate of what the density of the area would be if it were fully developed, calculate the associated population, assume that the population would be reached in fifty years, and draw a straight line between that number and the initial population. In other cases the methodology was much more elaborate, as some of the case studies testify.

VI Current Growth Rate Per Decade - This figure is an estimate of the population growth in the service area from 1960 to 1970. It was obtained from the engineers' reports if possible, however in most cases the reports did not present this information. Consequently we usually relied upon 1970 U.S. census data in making the estimate ourselves. Where the project service area did not coincide with a census jurisdiction, growth rate in the service area was assumed to be proportional to the most appropriate jurisdiction for which census data was available. For example if the service area is located in the rapidly growing suburban region of a slow growing central city we might assume that it had the same ten year percentage growth as the county or SMSA outside the city. The ten year growth is employed in calculating the implied years to capacity, which is discussed below.

VII Implied Years to Design - This is the measure of excess capacity which has been suggested by the CEQ. Under the assumption of linear growth rates and a 50 year design life for interceptors, this measure is proportional to the ratio of the growth rate employed by the designer to the current growth rate. It has been computed as follows:

$$\text{Implied Years} = \frac{\text{Ultimate(Design) Population} - \text{Initial Population}}{\text{Growth Rate Per Decade}/10}$$

Wherever possible the ultimate population has been employed since this is more indicative of the interceptor capacity. If this measure was not available the design population would be employed. The superscript U indicates that the calculation is based upon ultimate population, D indicates design population.

VIII Design Year - This serves as a reference point against which the implied years can be compared and indicates general engineering practices with respect to design periods. The year corresponding to ultimate capacity is given if possible and indicated with the superscript U. If information on the ultimate design was not available, the year corresponding the the design population (IV) is listed and indicated with the superscript D. The years were taken from the same sources as the associated population projections. Interestingly enough, we noted that in many cases the design year for a project would remain the same even though there had been considerable delay in obtaining funding. Thus a project designed in 1968 for a 1990 population would keep 1990 as the design year even though there might have been a five year delay in startup. The most common ultimate year was 2020 while the most common system design year was 1990.

IX Service Area Size - The ultimate area to be served by the system or interceptor, in acres. This was usually obtained from the engineering reports. Often this figure differs from the initial service area of the project since the area to be included in future extensions of the system or interceptor is also included, provided that capacity to handle these extensions is built into the current project.

X Percent Developable, Vacant Land - That portion of the service area (IX) which is currently unsewered, vacant and developable. This piece of information was generally not available in engineering reports. It was obtained instead from discussions with project engineers and local officials and, in several cases, from our own analysis of available land use maps. Although in the latter case we attempted to apply a consistent methodology in calculating this information the estimates can be regarded as crude at best. Moreover it is difficult to assess the accuracy of the information obtained in interviews. In general we have defined vacant land as land with a gross density of less than approximately one dwelling unit per ten acres. We also excluded from the developable category wetlands or other critical environmental areas unless there was a strong indication that these areas would not be protected.

XI Ultimate Density, in Persons Per Acre - The projected gross density (including roads, open spaces, etc.) which will be obtained in the developable, vacant (X) portion of the service area when the ultimate population is reached. Where possible this information was obtained from the engineering reports. Otherwise it was calculated by the following formula:

$$\text{Ultimate Density} = \frac{\text{Ultimate Population} - \text{Initial Population}}{(\text{Service Area Size})\ (\text{\% Developable, vacant})}$$

Although this figure gives some indication of the extent to which "sprawl" type development will occur in the service area it does not enable one to distinguish between traditional signle lot residential development and more modern cluster type developments, both of which may give the same gross density.

XII Residential Design Flow, in MGD - Where possible the ultimate average residential flow was given and designated with the superscript U, otherwise the system design residential flow was given and designated with the superscript D. This figure was obtained from engineering reports, if available. If the report did not list the flow but did give interceptor diameter the average flow was estimated from Manning's formula by assuming a minimum slope and applying the appropriate ratio of peak to average flow. Although we attempted to separate residential from industrial flow in all cases, in some projects consulting engineers lumped this flow with the residential flow and it was impossible to separate the two components. Thus the residential flow includes some industrial contribution in several projects. Where we feel that this is a serious difficulty in interpreting the data it has been so footnoted.

XIII Industrial Design Flow, in MGD - The comments under XII above apply here as well.

XIV Initial Residential Flow, in MGD - This is the flow corresponding to the initial population (III) and was obtained from engineering reports. It can be employed in conjunction with the initial population to determine the extent to which estimated current per capita waste generation rates agree with those projected for the future. The discussion on the difficulties encountered in separating residential from industrial flow in (XII) above applies here as well.

XV Initial Industrial Flow, in MGD - The industrial flow corresponding to project completion. See the discussion in XII above.

XVI Per Capita Design Flow, in gpcd - The per capita flow nominally employed by the engineers in sizing system components, usually 100. Upon examination of the data we found that this figure meant different things depending upon the engineer and the project. In some cases it included equivalent industrial flow and/or infiltration, in others it included only residential flow.

XVII Implied Per Capita Flow, in gpcd - This was calculated as:

$$\text{Implied Per Capita Flow} = \frac{\text{Ultimate (Design) Residential Flow}}{\text{Ultimate (Design Population}}$$

This measure serves two purposes. First, it provides a consistency check upon our flow and population data. Secondly it aides in interpreting the actual meaning of the nominal per capita flow (XVI).

XVIII Ratio of Peak to Average Flow - This is the ratio by which the ultimate residential flow (XII) has been multiplied in sizing the interceptors. Design practices in this regard differed from state to state but were relatively uniform within each state. Usually a constant factor was applied independent of the design flow, the most common factors being 2.0 and 2.5. In some cases the engineers employed design curves in which the ratio decreases with increasing population served. In cases where only the peak capacity of the interceptor was available, the ratio was used to obtain the average ultimate flow.

XIX Interceptor Diameter, in Inches - The diameter of the largest section of the interceptor or the largest interceptor in a system. Where better data was not available the diameter was used to estimate the ultimate interceptor capacity using Manning's Formula and assuming minimum slope.

XX Cost, in Dollars - The construction cost of the gravity sewers, force mains, and associated pumping stations in the project. Land acquisition, legal and engineering fees and contingencies have been excluded from the costs where possible. This information was usually obtained from the consutant engineers' estimates and therefore may be out of date in some cases. The range of dates associated with the cost estimates is 1972-1974. Despite this difficulty, the economic analysis in Section III indicates that the overall consistency of these data is quite good.

XXI Length, in Miles - The number of miles of gravity sewers and force mains in the projects. This was obtained from engineers' reports where possible or measured from maps of the project. The length serves one indication of the possible effects of the project, since generally the longer the interceptor the more land which is made addessible to sewerage. The length also was employed to scale the costs to a unit basis for the economic analysis in Section III.

Note: Wherever possible in the tables which follow we have supplied information most relevant to the interceptors in the project. Thus if enough information was available to separate individual interceptors in a project, this was done. Wherever possible ultimate data for implied years to design, design year, and flow were given since interceptors are generally designed for the ultimate capacity of a project. System design data, denoted by the superscript D, is most appropriate when considering the capacities of the treatment plants and pumping stations and therefore were given only if the ultimate data were unavailable.

APPENDIX B

DATA USED IN ANALYSIS
OF FIFTY INTERCEPTOR PROJECTS

REGION 2

New Jersey

I.	PROJECT NUMBER	340-356	340-379	C-340-358	C-340-312
II.	PROJECT LOCATION	Ocean County North	South--Year*	Pemberton	Bayshore Region
III.	INITIAL POPULATION	173,500[1]	65,000	12,300	32,000
IV.	DESIGN POPULATION	402,000	189,000	25,000	39,790
V.	ULTIMATE POPULATION	402,000	189,000	70,000	215,900
VI.	CURRENT GROWTH RATE PER DECADE	131,860	29,400	3,700	---
VII.	IMPLIED YEAR TO DESIGN	30^{U}	42^{U}	160^{U}	---
VIII.	DESIGN YEAR	2020^{U}	2020^{U}	1985	1985
IX.	SERVICE AREA SIZE (ACRES)	70,400	85,760	41,280	10,000
X.	VACANT DEVELOPABLE LAND (%)	50	40	96	45
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	11.4	5.5	10.3[3]	10.26^{U}
XII.	DESIGN RESIDENTIAL FLOW (MGD)	39.56^{U}	26.85^{U}	2.5^{D}	37.5^{U}
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	3.3^{U}	---	---	---
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	15.05[1]	12.94[1]	1.25	3.5
XV.	INITIAL INDUSTRIAL FLOW (MGD)	1.2	---	---	1.2
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100	100[2]	100	---
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	98	98	100	---
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	4 - 2	4 - 2	4.1	---
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	60	72	42	
XX.	INTERCEPTOR COST ($)	$42,000,000	$4,500,000	$9,699,000	$5,868,789
XXI.	INTERCEPTOR LENGTH (MILES)	84	42	5	10.6
XXII.	NUMBER OF INTERCEPTOR	16	10		

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

*Summer--Initial population, 180,000. Design population, 313,000.
Ultimate population, 313,000.

I.	PROJECT NUMBER	(C-340-312)			
II.	PROJECT LOCATION	Chingarora	Flat Creek	East Creek	Waackaack Creek
III.	INITIAL POPULATION				
IV.	DESIGN POPULATION				
V.	ULTIMATE POPULATION	77,500[4]	18,000	10,700	42,200
VI.	CURRENT GROWTH RATE PER DECADE				
VII.	IMPLIED YEAR TO DESIGN				
VIII.	DESIGN YEAR	2020	2020	2020	2020
IX.	SERVICE AREA SIZE (ACRES)				
X.	VACANT DEVELOPABLE LAND (%)				
XI.	ULTIMATE DENSITY (PERSONS/ACRE)				
XII.	DESIGN RESIDENTIAL FLOW (MGD)	10.0[U]	1.85[U]	1.40[U]	6.04[U]
XIII.	DESIGN INDUSTRIAL FLOW (MGD)				
XIV.	INITIAL RESIDENTIAL FLOW (MGD)				
XV.	INITIAL INDUSTRIAL FLOW (MGD)				
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100	100	100	100
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	129	103	131	143
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2.8	2.7	2.93	2.15
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	54"	24"	24"	30"
XX.	INTERCEPTOR COST ($)				
XXI.	INTERCEPTOR LENGTH (MILES)	3.7	1.4	2.5	1.4
XXII.	NUMBER OF INTERCEPTOR				

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

I.	PROJECT NUMBER	(C-340-312)	340-338	340-344
II.	PROJECT LOCATION	Union Beach	Parsippany Troy Hills	Atlantic County
III.	INITIAL POPULATION	147,500	55,112	136,533[6]
IV.	DESIGN POPULATION		---	---
V.	ULTIMATE POPULATION		109,698	375,480
VI.	CURRENT GROWTH RATE PER DECADE		29,479	11,000[7]
VII.	IMPLIED YEAR TO DESIGN		18.5[U]	126[U]
VIII.	DESIGN YEAR	2020	2010	2010
IX.	SERVICE AREA SIZE (ACRES)		15,170	149,000
X.	VACANT DEVELOPABLE LAND (%)		39	40[8]
XI.	ULTIMATE DENSITY (PERSONS/ACRE)		14.0	2.4[9]
XII.	DESIGN RESIDENTIAL FLOW (MGD)	18.67[U]	11.9[U]	45.3[U]
XIII.	DESIGN INDUSTRIAL FLOW (MGD)		5.8	---
XIV.	INITIAL RESIDENTIAL FLOW (MGD)		---	31.9[6]
XV.	INITIAL INDUSTRIAL FLOW (MGD)		---	---
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100	100	100
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	127	108	121
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2.21	2.5	2 - 4
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	60	72	36 Force
XX.	INTERCEPTOR COST ($)		$3,266,000	$29,900,000
XXI.	INTERCEPTOR LENGTH (MILES)	1.6	2.01	
XXII.	NUMBER OF INTERCEPTOR			

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

New Jersey

[1] 1980 - Initial year.

[2] Assume 75/capita/day for summer residents.

[3] Density calculated on basis of land presently zoned residential. If all residentially zoned and vacant land were developed for residences, density would be 2.35/acres.

[4] Assumes full expansion of system to include Keyport, Matawan Borough and township, and the northerly part of Marlborough.

[5] Includes Keansburg.

[6] Includes equivalent industrial and summer.

[7] Based upon Atlantic County growth rate.

[8] Assumes no development in coastal zone under Coastal Zone Management Act--USR&E estimate from maps.

[9] Includes seasonal inhabitants, assumes industrial equivalents accounts for 10% of 2010 flows

New York

I.	PROJECT NUMBER	360-643	360-389	360-556
II.	PROJECT LOCATION	Saratoga-- District #1	Rensselaer	Rockland County
III.	INITIAL POPULATION	79,000	91,580	14,675
IV.	DESIGN POPULATION	156,600	124,100	24,000
V.	ULTIMATE POPULATION	156,600	191,400	24,000
VI.	CURRENT GROWTH RATE PER DECADE	19,750	5,992[1]	5,940
VII.	IMPLIED YEAR TO DESIGN	39^{U}	17^{U}	15^{U}
VIII.	DESIGN YEAR	2020^{U}	1990^{D}	2020^{U}
IX.	SERVICE AREA SIZE (ACRES)	119,168	41,280	2,475
X.	VACANT DEVELOPABLE LAND (%)	60	60	52
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	1.1	4.1	16[2]
XII.	DESIGN RESIDENTIAL FLOW (MGD)	15.66	12.41^{D}	2.62^{U}
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	4.5^{U}	12.97^{D}	$.18^{U}$
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	4.11	9.135	1.76
XV.	INITIAL INDUSTRIAL FLOW (MGD)	2.94	12.21	.16
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100	100	120
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	100	100	109
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2.5	2.5-4	3.8 - 2.6
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	54	---	18 gravity 20 force
XX.	INTERCEPTOR COST ($)	$11,340,000	$32,100,000	$3,877,000
XXI.	INTERCEPTOR LENGTH (MILES)	18.8		3.6 gravity, 3.7 force
XXII.	NUMBER OF INTERCEPTOR		3	

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

I.	PROJECT NUMBER			
II.	PROJECT LOCATION	Oakwood Beach	Interceptor 6C	Interceptor EL18
III.	INITIAL POPULATION	175,000		
IV.	DESIGN POPULATION	285,000		
V.	ULTIMATE POPULATION	590,000		
VI.	CURRENT GROWTH RATE PER DECADE	43,420[3]		
VII.	IMPLIED YEAR TO DESIGN	96[U]		
VIII.	DESIGN YEAR	1986[D]		
IX.	SERVICE AREA SIZE (ACRES)	22,500		
X.	VACANT DEVELOPABLE LAND (%)	57		
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	26		
XII.	DESIGN RESIDENTIAL FLOW (MGD)	28.7[D]		
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	0.0		
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	9.07		
XV.	INITIAL INDUSTRIAL FLOW (MGD)	0.0		
XVI.	DESIGN PER CAPITA FLOW (GPCD)	120		
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	---		
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2		
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	---	90	78
XX.	INTERCEPTOR COST ($)	$41,800,000	$25,000,000	$16,800,000
XXI.	INTERCEPTOR LENGTH (MILES)	3.84	1.8	2.04
XXII.	NUMBER OF INTERCEPTOR			

U = Ultimate Capacity, generally to the year 2020; may be itnerpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

New York

[1] Based on Rensselaer County Growth 1960-1970.

[2] Based upon assumption that 985 acres are either used for recreation or are unsuitable for development.

[3] Based on Richmond County growth rate 1960-1970.

REGION 4

ALABAMA

I.	PROJECT NUMBER	0 10-232	0 10-232
II.	PROJECT LOCATION	North Tuskegee	South Tuskegee
III.	INITIAL POPULATION	7,653	6,210
IV.	DESIGN POPULATION	13,130	11,560
V.	ULTIMATE POPULATION	13,130	11,560
VI.	CURRENT GROWTH RATE PER DECADE	2,726	2,211
VII.	IMPLIED YEAR TO DESIGN	20^{U}	24^{U}
VIII.	DESIGN YEAR	2020^{U}	2020^{U}
IX.	SERVICE AREA SIZE (ACRES)	9,143	9,143
X.	VACANT DEVELOPABLE LAND (%)	60	60
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	2.4	2.1
XII.	DESIGN RESIDENTIAL FLOW (MGD)	1.17^{U}	.86^{U}
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	--	--
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	--	--
XV.	INITIAL INDUSTRIAL FLOW (MGD)	--	--
XVI.	DESIGN PER CAPITA FLOW (GPCD)	115	115
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	100	100
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	3.5	3.5
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	24	24
XX.	INTERCEPTOR COST ($)	1,651,000	643,000
XXI.	INTERCEPTOR LENGTH (MILES)	17.4	12.7
XXII.	NUMBER OF INTERCEPTOR		

U = Ultimate capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design capacity, generally determined by the capacity of the treatment plant or pumping plant.

FLORIDA

I.	PROJECT NUMBER	120-477 +120-266		
II.	PROJECT LOCATION	Altamonte Springs-Lonewood-System	Longwood Interceptor	West Altamonte Springs & Montgomery Rd. Interceptor
III.	INITIAL POPULATION	50,009	--	--
IV.	DESIGN POPULATION	82,888	--	--
V.	ULTIMATE POPULATION	--	--	--
VI.	CURRENT GROWTH RATE PER DECADE	24,231[1]	--	--
VII.	IMPLIED YEAR TO DESIGN	14[D]	--	--
VIII.	DESIGN YEAR	1990[D]	2000[U]	2000[U]
IX.	SERVICE AREA SIZE (ACRES)	--	--	--
X.	VACANT DEVELOPABLE LAND (%)	--	--	--
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	--	--	--
XII.	DESIGN RESIDENTIAL FLOW (MGD)	7.5[D]	--	--
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	0.0	--	--
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	1.5	--	--
XV.	INITIAL INDUSTRIAL FLOW (MGD)	0.0	--	--
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100	--	--
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	--	--	--
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	--	--	--
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	--	--	--
XX.	INTERCEPTOR COST ($)	$2,916,000	$696,000	$2,220,000
XXI.	INTERCEPTOR LENGTH (MILES)	8.45	.91 Force, 2.52 Gravity	5.02
XXII.	NUMBER OF INTERCEPTOR	3		2

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

Florida

[1] Assumes growth of total area is the same as that for Altamonte Springs and Longwood or 94% from 1960 to 1970.

GEORGIA

I.	PROJECT NUMBER	130-328	130-330	130-350
II.	PROJECT LOCATION	Jackson	Jeffersonville	Sugar Hill
III.	INITIAL POPULATION	3,778	1,440	1,850
IV.	DESIGN POPULATION	9,300	2,100	4,180
V.	ULTIMATE POPULATION	--	2,500	--
VI.	CURRENT GROWTH RATE PER DECADE	1,233	289	--
VII.	IMPLIED YEAR TO DESIGN	40^D	23^U	--
VIII.	DESIGN YEAR	2010	1985	$2,000^D$
IX.	SERVICE AREA SIZE (ACRES)	1,000	2,373	2,560
X.	VACANT DEVELOPABLE LAND (%)	80	40^2	10
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	--	1.05^{US}	--
XII.	DESIGN RESIDENTIAL FLOW (MGD)	$.7^D$ South, .85 N.E.	$.21^D$	--
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	$.2^D$ South, .05 N.E.	0	--
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	.06 South, .073 N.E.	.15	.185
XV.	INITIAL INDUSTRIAL FLOW (MGD)	.2 South, .05 NE.	0	0.0
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100	100	--
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	167	120	--
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2.5	--	--
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	15	12	10
XX.	INTERCEPTOR COST ($)	$250,000	$657,692	--
XXI.	INTERCEPTOR LENGTH (MILES)	9.09	15.7^3	7.5
XXII.	NUMBER OF INTERCEPTOR	2		

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

I.	PROJECT NUMBER	130-312		130-333	030-189
II.	PROJECT LOCATION	Buford-- South	Buford-- West	Fulton City Cater Creek Interceptor	North Fulton Co. Big Creek
III.	INITIAL POPULATION	5,004	500	2,380	6,798
IV.	DESIGN POPULATION	18,000	6,000	9,368	70,857
V.	ULTIMATE POPULATION	18,000	6,000	--	160,946
VI.	CURRENT GROWTH RATE PER DECADE	2,875	143	716^{6}	--
VII.	IMPLIED YEAR TO DESIGN	610^{U}	385^{U}	97^{D}	--
VIII.	DESIGN YEAR	2000	2000	1988^{D}	--
IX.	SERVICE AREA SIZE (ACRES)	9,000	3,000	735	22,089
X.	VACANT DEVELOPABLE LAND (%)	--	--	75	85
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	2	2	--	7
XII.	DESIGN RESIDENTIAL FLOW (MGD)	1.35^{U}	.45^{U}	1.0^{D}	16.0
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	.45^{U}	.15^{U}	0.0	0
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	--	--	.16	--
XV.	INITIAL INDUSTRIAL FLOW (MGD)	--	--	0.0	--
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100	100	100	100
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	100	100	106	100
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2	2	2.5 - 4	2.5
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	24	16	18	60
XX.	INTERCEPTOR COST ($)	$281,722	$73,460	$248,935	$2,380,000
XXI.	INTERCEPTOR LENGTH (MILES)	.5	.4	1.94	13.3
XXII.	NUMBER OF INTERCEPTOR				

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

I.	PROJECT NUMBER	030-189		
II.	PROJECT LOCATION	North Fulton Co. Foe Killer	Ball Mill Creek	Sullivans Creek/ Pitts Road
III.	INITIAL POPULATION	3,101	1,550	--
IV.	DESIGN POPULATION	22,089	20,880	20,000
V.	ULTIMATE POPULATION	34,271	40,922	25,100
VI.	CURRENT GROWTH RATE PER DECADE	--	--	--
VII.	IMPLIED YEAR TO DESIGN	--	--	--
VIII.	DESIGN YEAR	--	--	--
IX.	SERVICE AREA SIZE (ACRES)	7,529	3,766	3,000
X.	VACANT DEVELOPABLE LAND (%)	25	85	85
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	1 - 5	5 - 10	5 - 10
XII.	DESIGN RESIDENTIAL FLOW (MGD)	3.4	4[U]	2.5[U]
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	0	0	0
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	--	--	--
XV.	INITIAL INDUSTRIAL FLOW (MGD)	--	--	--
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100	100	100
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	100	100	100
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2.5	2.5	2.5
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	30	18	30
XX.	INTERCEPTOR COST ($)	$1,190,000	$1,240,000	$1,188,000
XXI.	INTERCEPTOR LENGTH (MILES)	4.5	1.4	
XXII.	NUMBER OF INTERCEPTOR			2

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

Georgia

[1] Assumes all of Jeffersonville sewered, 1975 starting date.

[2] "Eyeball" estimate.50% of currently undeveloped land within city is developable.

[3] Includes only pipes greater than 8".

[4] Current population of Buford which is not sewered is assumed to be distributed equally between the two service areas.

[5] Assumes all new growth in presently unsewered areas.

[6] Assumes 1/2 population of Union City is iwthin the basin in 1960 and 1970. 865 persons live beyond the city limits in 1970; growth rate of Union City, 1960-1970, = 43%.

MISSISSIPPI

I.	PROJECT NUMBER	80-316	80-358-010	280-344
II.	PROJECT LOCATION	Richland	Marion	Southaven-West Southaven Interceptor
III.	INITIAL POPULATION	4,200	800	3,000[2]
IV.	DESIGN POPULATION	10,000	3,000	3,000
V.	ULTIMATE POPULATION	20,000	15,680[1]	3,000
VI.	CURRENT GROWTH RATE PER DECADE	4,200	155	---
VII.	IMPLIED YEAR TO DESIGN	38[U]	142[D]	---
VIII.	DESIGN YEAR	1990[D]	1990[D]	1985[U]
IX.	SERVICE AREA SIZE (ACRES)	9,000	2,240	2,460
X.	VACANT DEVELOPABLE LAND (%)	67.5	70	50
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	3.3	10	(3)
XII.	DESIGN RESIDENTIAL FLOW (MGD)	1.0[D]	.3[D]	.3
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	3.0[D]	---	2.3
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	.44	.08	.3
XV.	INITIAL INDUSTRIAL FLOW (MGD)	---	---	0.0
XVI.	DESIGN PER CAPITA FLOW (GPCD)	97	100	100
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	100	100	100
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	4.0-2.5	---	3.0
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	27	10	24
XX.	INTERCEPTOR COST ($)	$1,340,000	$221,900	$512,000
XXI.	INTERCEPTOR LENGTH (MILES)	5.06	4.16 Gravity 0.2 Force Main	Gravity 1.8, Force .4
XXII.	NUMBER OF INTERCEPTOR	4		

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

I.	PROJECT NUMBER	
II.	PROJECT LOCATION	West Greenbrook Interceptor
III.	INITIAL POPULATION	0.0
IV.	DESIGN POPULATION	19,200
V.	ULTIMATE POPULATION	19,200
VI.	CURRENT GROWTH RATE PER DECADE	---
VII.	IMPLIED YEAR TO DESIGN	---
VIII.	DESIGN YEAR	1985^{U}
IX.	SERVICE AREA SIZE (ACRES)	640
X.	VACANT DEVELOPABLE LAND (%)	90
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	30
XII.	DESIGN RESIDENTIAL FLOW (MGD)	1.9^{U}
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	---
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	---
XV.	INITIAL INDUSTRIAL FLOW (MGD)	---
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	100
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	3.0
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	24
XX.	INTERCEPTOR COST ($)	$428,000
XXI.	INTERCEPTOR LENGTH (MILES)	Gravity 1.3, Force .6
XXII.	NUMBER OF INTERCEPTOR	

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

Mississippi

[1] Population figures only available for entire utility district--USR&E estimates for interceptors based upon service area and land use projection in planning reports.

[2] Overflow for existing trunk.

[3] Most of new growth will be industrial and commercial.

SOUTH CAROLINA

I.	PROJECT NUMBER	450-284	450-276	450-287
II.	PROJECT LOCATION	Columbia	Greenville	Greenville
III.	INITIAL POPULATION	5,036	4,700	4,500
IV.	DESIGN POPULATION	35,241	29,000[2]	20,000
V.	ULTIMATE POPULATION	--	29,000[2]	--
VI.	CURRENT GROWTH RATE PER DECADE	713[1]	940[3]	900[3]
VII.	IMPLIED YEAR TO DESIGN	494[D1]	309[D3]	222[D3]
VIII.	DESIGN YEAR	1990[D]	2003[U]	2000[D]
IX.	SERVICE AREA SIZE (ACRES)	1,920	7,500	--
X.	VACANT DEVELOPABLE LAND (%)	65	75	75
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	25	4[2]	3.5
XII.	DESIGN RESIDENTIAL FLOW (MGD)	12.6[D]	5.1[U2]	3.0
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	1.4[D]	--	0.0
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	--	.6	--
XV.	INITIAL INDUSTRIAL FLOW (MGD)	0.0	.1	0.0
XVI.	DESIGN PER CAPITA FLOW (GPCD)	250	--	125
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	358	177[2]	150
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	--	3.05-4.15[4]	--
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	21	27	24
XX.	INTERCEPTOR COST ($)	2,225,403	1,304,669	773,000
XXI.	INTERCEPTOR LENGTH (MILES)	5.1	4.5	2.7
XXII.	NUMBER OF INTERCEPTOR			

U = Ultimate capacity, generally to the year 2000; may be interpreted as interceptor capacity.

D = Design capacity, generally determined by the capacity of the treatment plant or pumping plant.

SOUTH CAROLINA

I.	PROJECT NUMBER	450-287	450-314	450-264	
II.	PROJECT LOCATION	Greenville	Walterboro[5]	N. Myrtle Beach	
III.	INITIAL POPULATION	400	250	1,957 Year-round	48,000 Summer
IV.	DESIGN POPULATION	10,500	2,000	4,300	65,000
V.	ULTIMATE POPULATION	--	2,000	--	--
VI.	CURRENT GROWTH RATE PER DECADE	80[3]	--	255[6]	
VII.	IMPLIED YEAR TO DESIGN	1,313^{D}[3]	--	92^{D}	
VIII.	DESIGN YEAR	2000^{D}	1990^{U}	2000^{D}	
IX.	SERVICE AREA SIZE (ACRES)	--	< 640	5600	
X.	VACANT DEVELOPABLE LAND (%)	--	90	60	
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	--	5	--	
XII.	DESIGN RESIDENTIAL FLOW (MGD)	1.1^{D}[2]	--	.65 Year-round	2.2 Summer
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	--	--	--	
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	.4	.095	.3	1.5
XV.	INITIAL INDUSTRIAL FLOW (MGD)	.155	0.0	0.0	
XVI.	DESIGN PER CAPITA FLOW (GPCD)	-	--	150	
XVII.	IMPLIED PER CAPITA FLOW (EPCD)	105	--	150	32
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	--	--	--	
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	18	10 5	12	
XX.	INTERCEPTOR COST ($)	103,000	254,610	1,273,670	
XXI.	INTERCEPTOR LENGTH (MILES)	1.08	1.55 Gravity .76 Force	24'	
XXII.	NUMBER OF INTERCEPTOR				

U = Ultimate capacity, generally to the year 2000; may be interpreted as interceptor capacity.

D = Design capacity, generally determined by the capacity of the treatment plant or pumping plant.

South Carolina

[1] Assumes Columbia growth rate of 16.5%.

[2] Equivalent, including industrial.

[3] Assumes growth rate of county outside of Greenville city limits.

[4] Based on assumed per capita of 100 gpcd.

[5] Total collection system.

[6] Assumed growth rate same as for all of Myrtle Beach 1960-1970 = 15% year round residents only.

TENNESSEE

I.	PROJECT NUMBER	470-274	470-310	280-350
II.	PROJECT LOCATION	Hallsdale-Powell	Nashville	Horn Lake Creek-Tennessee & Mississippi
III.	INITIAL POPULATION	24,400	99,032	34,000
IV.	DESIGN POPULATION	-	180,300	208,000
V.	ULTIMATE POPULATION	168,000	223,019	410,000
VI.	CURRENT GROWTH RATE PER DECADE	8,760[1]	160,431	11,364
VII.	IMPLIED YEAR TO DESIGN	164^{U}	5^{D}	330^{U}
VIII.	DESIGN YEAR	2020^{U}	2000^{D}	2000^{U}
IX.	SERVICE AREA SIZE (ACRES)	55,040	107,399	40,000
X.	VACANT DEVELOPABLE LAND (%)	70	60	60
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	4.36	2.1	12
XII.	DESIGN RESIDENTIAL FLOW (MGD)	5.44^{2U}	27.04^{D}	16.0^{D}
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	$.96^{2U}$	30.82^{D}	11.3^{D}
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	-	14.65^{D}	-
XV.	INITIAL INDUSTRIAL FLOW (MGD)	-	9.76^{D}	-
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100	150	100
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	(3)	150	77
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2.5	2	2.5
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	36	72	96
XX.	INTERCEPTOR COST ($)	4,245,660	20,790,000	15,862,000
XXI.	INTERCEPTOR LENGTH (MILES)	19	21.3	21.3
XXII.	NUMBER OF INTERCEPTOR		3	

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

TENNESSEE

I.	PROJECT NUMBER	470-333	470-333	470-374
II.	PROJECT LOCATION	Goodlettsville North A	Goodlettsville South B	Murfreesboro
III.	INITIAL POPULATION	640[4]	320[4]	1970 26,360
IV.	DESIGN POPULATION	--	--	40,000
V.	ULTIMATE POPULATION	17,120[5]	2,560[5]	40,000
VI.	CURRENT GROWTH RATE PER DECADE	603	301	7,369
VII.	IMPLIED YEAR TO DESIGN	270[U]	64[U]	19[D]
VIII.	DESIGN YEAR	1990[D]	1990[D]	1990[D]
IX.	SERVICE AREA SIZE (ACRES)	400 now[6] 1400 ult[7]	200 now[6] 400 ult[7]	ultimate 18,575
X.	VACANT DEVELOPABLE LAND (%)	50	50	--
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	6	6	2.1
XII.	DESIGN RESIDENTIAL FLOW (MGD)	8[U]	0.4[U]	4.0[U]
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	--	--	1.33[U]
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	.1	.05	2.6[U]
XV.	INITIAL INDUSTRIAL FLOW (MGD)	--	--	--
XVI.	DESIGN PER CAPITA FLOW (GPCD)	167	167	100
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	467	122	100
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2.5	3.2	3.0
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	42	15	42
XX.	INTERCEPTOR COST ($)	383,730	46,532	2,060,000
XXI.	INTERCEPTOR LENGTH (MILES)	1.4	.43	3.03
XXII.	NUMBER OF INTERCEPTOR			

U = Ultimate capacity, generally to the year 2000; may be interpreted as interceptor capacity

D = Design capacity, generally determined by the capacity of the treatment plant or pumping plant.

TENNESSEE

I.	PROJECT NUMBER	470-272	470-281	
II.	PROJECT LOCATION	Washington County	Bolivar	
III.	INITIAL POPULATION	17,326	2,500[8]	500
IV.	DESIGN POPULATION	31,200	2,500[8]	800
V.	ULTIMATE POPULATION	--	--	
VI.	CURRENT GROWTH RATE PER DECADE	2,128	250	
VII.	IMPLIED YEAR TO DESIGN	65[D]	12[D]	
VIII.	DESIGN YEAR	1990[D]	1990[D]	
IX.	SERVICE AREA SIZE (ACRES)	--	2,560	
X.	VACANT DEVELOPABLE LAND (%)	82	60	
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	--	2.1	
XII.	DESIGN RESIDENTIAL FLOW (MGD)	3.0[D]	.33[D]	
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	--	--	
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	--	.24	
XV.	INITIAL INDUSTRIAL FLOW (MGD)	--	--	
XVI.	DESIGN PER CAPITA FLOW (GPCD)	--	--	
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	96	100	
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2.5	--	
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	18	12	10
XX.	INTERCEPTOR COST ($)	4,024,000[7]	214,000	168,000
XXI.	INTERCEPTOR LENGTH (MILES)	86.8[7]	1.3 Gravity 1.25 Force	1.6 Gravity 1.1 Force
XXII.	NUMBER OF INTERCEPTOR		(West Interceptor)	(East Interceptor)

U = Ultimate capacity, generally to the year 2000; may be interpreted as interceptor capacity.

D = Design capacity, generally determined by the capacity of the treatment plant or pumping plant.

Tennessee

[1] Based upon growth rate for Knoxville, Tennessee, 1960-1970.

[2] USR&E estimates based upon minimum slope.

[3] Calculation inconsistent with our flow estimates.

[4] Assume 2/3, 1/3 split of households in engineers report and 3.2 persons/household.

[5] Assumes 6.4/acre for all of south and 1,200 acres of north; 200 acres of north at 40/acre.

[6] Eyeball estimate = 800 acres residential, 200 acres of commercial.

[7] Project includes complete collection system.

[8] State hospital assumed constant population 2,500.

REGION 6

ARKANSAS

I.	PROJECT NUMBER	C-05-343-010	050-350-010	C-05-0304-010	C-05-0360-010
II.	PROJECT LOCATION	Little Rock	Greenbrier	Benton	Van Buren
III.	INITIAL POPULATION	40,000	720	16,500	9,125
IV.	DESIGN POPULATION	139,850	1,470	30,000	14,000
V.	ULTIMATE POPULATION	278,000	2,250	30,000	--
VI.	CURRENT GROWTH RATE PER DECADE	$8{,}500^1$	173^2	6,500	$1{,}195^3$
VII.	IMPLIED YEAR TO DESIGN	280^U	88.5^U	22^U	49^D
VIII.	DESIGN YEAR	2015^U	2002^U	2010^U	1990^D
IX.	SERVICE AREA SIZE (ACRES)	--	4,800	--	916
X.	VACANT DEVELOPABLE LAND (%)	85	70	20	55
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	10	--	--	8
XII.	DESIGN RESIDENTIAL FLOW (MGD)	27^U	$.22^U$	2.7^U	2.1^D
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	--	--	--	--
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	4	.10	1.3	--
XV.	INITIAL INDUSTRIAL FLOW (MGD)	--	--	--	--
XVI.	DESIGN PER CAPITA FLOW (GPCD)	120	100	100	100
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	97	117	90	150
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2.0	2.0	2.0	3.0
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	72	10	24	15
XX.	INTERCEPTOR COST ($)	3,447,335	44,007	622,250	119,666.60
XXI.	INTERCEPTOR LENGTH (MILES)	3.65	2.8	5.37	2.0
XXII.	NUMBER OF INTERCEPTOR				

U = Ultimate capacity, generally to the year 2000; may be interpreted as interceptor capacity.

D = Design capacity, generally determined by the capacity of the treatment plant or pumping plant.

Arkansas

[1] Based on growth rate for City of Little Rock 1960-1970.

[2] Based on growth rate of Faulkner County 1960-1970.

[3] Based on growth rate of Van Buren County 1960-1970.

LOUISIANA

I.	PROJECT NUMBER	220-289-01-0	220-277-018	220-240-010
II.	PROJECT LOCATION	St. Bernard (District #2)	St. Tammany Parish, Madisonville	Shreveport
III.	INITIAL POPULATION	36,000	1,000	150,000
IV.	DESIGN POPULATION	81,000	2,500	220,000
V.	ULTIMATE POPULATION	(1)	2,500	--
VI.	CURRENT GROWTH RATE PER DECADE	13,500	390	16,000
VII.	IMPLIED YEAR TO DESIGN	33^{D}	38^{U}	43^{D}
VIII.	DESIGN YEAR	1978^{D}	2010^{U}	1984^{D}
IX.	SERVICE AREA SIZE (ACRES)	1,650	450^{2}	$47,168^{2}$
X.	VACANT DEVELOPABLE LAND (%)	70^{2}	75^{2}	75^{2}
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	(1)	(1)	--
XII.	DESIGN RESIDENTIAL FLOW (MGD)	2.4^{D}	$.25^{U}$	2.4^{D}
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	(3)	(3)	(3)
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	1.25	.150	.256
XV.	INITIAL INDUSTRIAL FLOW (MGD)	(3)	(3)	(3)
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100	100	110
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	29.6	100	10.9^{5}
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	3.3^{4}	3.0	1.5
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	36	12	60
XX.	INTERCEPTOR COST ($)	30,300	345,138	19,000,000
XXI.	INTERCEPTOR LENGTH (MILES)	.34	7.6	--
XXII.	NUMBER OF INTERCEPTOR			

U = Ultimate capacity, generally to the year 2000; may be interpreted as interceptor capacity.

D = Design capacity, generally determined by the capacity of the treatment plant or pumping plant.

Louisiana

[1] Not listed because of uncertainty regarding use of swamplands.

[2] Includes extensive swamplands.

[3] Industrial flow information not available at state offices.

[4] Includes allowance for excessive infiltration.

[5] Data appears inconsistent for design flow and design population.

OKLAHOMA

I.	PROJECT NUMBER	400-554	400-561	400-564	400-563
II.	PROJECT LOCATION	Ardmore	Edmund	Tulsa-Broken Arrow(1)	Tulsa(2)
III.	INITIAL POPULATION	High School plus 1,050	11,000	7,500	5,000 (total 12,500)
IV.	DESIGN POPULATION	9,000	40,000	11,040	7,360 (total 18,400
V.	ULTIMATE POPULATION	15,000	60,000	26,400	14,900 (total 41,300
VI.	CURRENT GROWTH RATE PER DECADE	36^1	8,056	4,960	1,311
VII.	IMPLIED YEAR TO DESIGN	$2,360^D$	61^U	38^U	75.5^U
VIII.	DESIGN YEAR	1990^D	1990^D	1980^D	1980^D
IX.	SERVICE AREA SIZE (ACRES)	644	6,080	2,640	1,490
X.	VACANT DEVELOPABLE LAND (%)	65	33	85	50
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	33	10	10	10
XII.	DESIGN RESIDENTIAL FLOW (MGD)	.8	3.7^D	2.64^U	1.49^U
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	.216	-	-	-
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	.19	1.1	.7	.2
XV.	INITIAL INDUSTRIAL FLOW (MGD)	.216	-	-	-
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100	100	100	100
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	100	92.5	100	100
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2.5	1.75	2.5	2.5
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	24	24	54	36
XX.	INTERCEPTOR COST ($)	308,902	842,660	1,529,000	853,000
XXI.	INTERCEPTOR LENGTH (MILES)	3	6.7	8.0	5.8
XXII.	NUMBER OF INTERCEPTOR	2		2	

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

Oklahoma

[1] Based on growth rate of entire town, 1960-1970.

TEXAS

I. PROJECT NUMBER	480-974	481-048		480-975
II. PROJECT LOCATION	La Marque	Baytown East	Central	Beaumont
III. INITIAL POPULATION	17,500	14,200	25,000	42,570
IV. DESIGN POPULATION	28,000	105,000	102,000	167,217
V. ULTIMATE POPULATION	28,000	105,000	102,000	-
VI. CURRENT GROWTH RATE PER DECADE	2,000	18,000[1]	12,000[1]	0
VII. IMPLIED YEAR TO DESIGN	52.5^U	50.50^U	64^U	∞
VIII. DESIGN YEAR	1990^D	1995^U	1995^U	1995^D
IX. SERVICE AREA SIZE (ACRES)	-	10,284	9,246	45,409
X. VACANT DEVELOPABLE LAND (%)	0	82	–	30
XI. ULTIMATE DENSITY (PERSONS/ACRE)	-	10.2	11.0	12.3
XII. DESIGN RESIDENTIAL FLOW (MGD)	3.1^D	12.0^D	-	30.9^U
XIII. DESIGN INDUSTRIAL FLOW (MGD)	0.0	–	–	–
XIV. INITIAL RESIDENTIAL FLOW (MGD)	1.8	2.16	-	5.5
XV. INITIAL INDUSTRIAL FLOW (MGD)	0.0	-	-	-
XV'. DESIGN PER CAPITA FLOW (GPCD)	111	100	100	100
XVII. IMPLIED PER CAPITA FLOW (GPCD)	111	114	-	185[2]
XVIII. RATIO OF PEAK TO AVERAGE FLOW	2.5	2.5	2.5	2.5
XIX. INTERCEPTOR MAXIMUM DIAMETER (INCHES)	36	54	21	72
XX. INTERCEPTOR COST ($)	370,400	750,000		5,920,000
XXI. INTERCEPTOR LENGTH (MILES)	1.8	3.15	.68	22.9 mi.
XXII. NUMBER OF INTERCEPTOR				3

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

I.	PROJECT NUMBER	480-989	480-990	481-117
II.	PROJECT LOCATION	Austin		San Leon Mud
III.	INITIAL POPULATION	6,046	1,000	5,000
IV.	DESIGN POPULATION	33,500	10,900	8,500
V.	ULTIMATE POPULATION	61,080	85,600[3]	45,000
VI.	CURRENT GROWTH RATE PER DECADE	2,511	416	868[4]
VII.	IMPLIED YEAR TO DESIGN	219[U]	2034[U]	461[U]
VIII.	DESIGN YEAR	1990[D]	1990[D]	1983[D]
IX.	SERVICE AREA SIZE (ACRES)	5,090	8,560	5,050
X.	VACANT DEVELOPABLE LAND (%)	70%	90%	50%
XI.	ULTIMATE DENSITY (PERSONS/ACRE)	12	10	18
XII.	DESIGN RESIDENTIAL FLOW (MGD)	6[U]	1.73[D]	.75[D]
XIII.	DESIGN INDUSTRIAL FLOW (MGD)	-	-	-
XIV.	INITIAL RESIDENTIAL FLOW (MGD)	.6	.16	.5
XV.	INITIAL INDUSTRIAL FLOW (MGD)	-	-	-
XVI.	DESIGN PER CAPITA FLOW (GPCD)	100	100	100
XVII.	IMPLIED PER CAPITA FLOW (GPCD)	97	158	88
XVIII.	RATIO OF PEAK TO AVERAGE FLOW	2.5	2.5	2.5
XIX.	INTERCEPTOR MAXIMUM DIAMETER (INCHES)	42	54 10 force main	>6
XX.	INTERCEPTOR COST ($)	578,216	467,317	700,000
XXI.	INTERCEPTOR LENGTH (MILES)	2.6 mi.	.57 mi. .8 mi.f.m.	14.26 >6 inch 19.00 mi. 6 inch 2.3 mi. f m.
XXII.	NUMBER OF INTERCEPTOR			

U = Ultimate Capacity, generally to the year 2020; may be interpreted as interceptor capacity.

D = Design Capacity, generally determined by the capacity of the treatment plant or pumping plant.

Texas

[1] Assumed growth 1960 to 1970 as tangent to consultants growth curve.

[2] Excessive infiltration problem.

[3] Based upon projected density, consultant's report.

[4] Based upon Texas City growth rate.